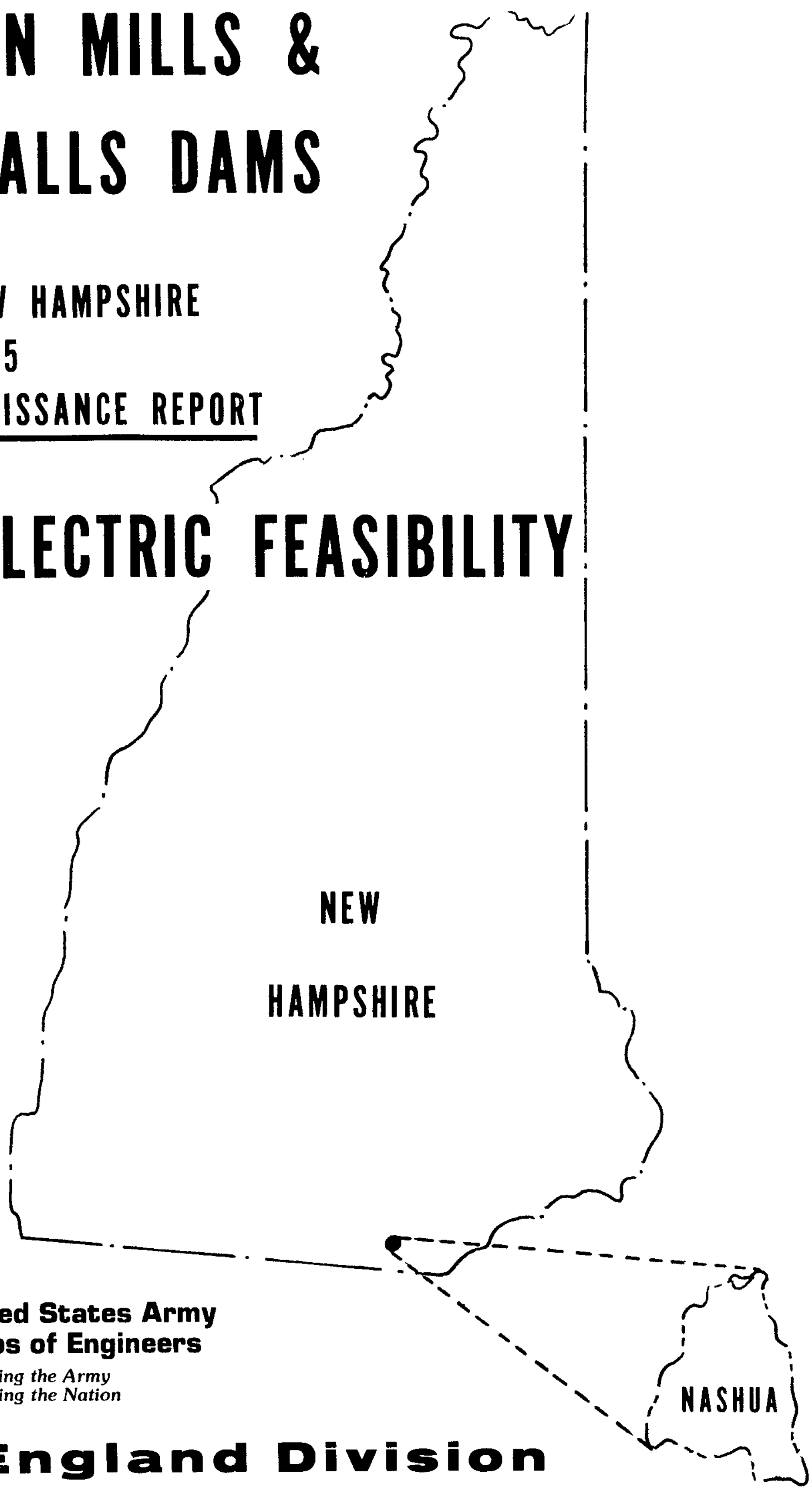
JACKSON MILLS & MINE FALLS DAMS

NASHUA, NEW HAMPSHIRE
CWIS # 14035
PRE-RECONNAISSANCE REPORT

HYDROELECTRIC FEASIBILITY

JUNE 1979



United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

New England Division

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, NEW HAMPSHIRE

C.W.I.S. - 14035

Pre-Reconnaissance Report
Hydroelectric Feasibility

June, 1979

EXECUTIVE SUMMARY

This Pre-Reconnaissance Report has assessed the feasibility of generating hydroelectric power at Jackson Mills and Mine Falls Dams in Nashua, New Hampshire. Both dams span the Nashua River and were built in the 1920's. It has been assumed for the purposes of this study that these projects would be funded and managed by the City of Nashua and that the power would be sold directly to Public Service Company of New Hampshire at the established rate of 4¢/kwh. The projects are each expected to have minimum lifespan of 40 years.

At Jackson Mills, four alternatives for generating power were evaluated. The selected plan would require the construction of a new powerhouse between the south abutment of the dam and the Nashua Public Library. The powerhouse would contain two horizontal shaft axial-flow turbines, each capable of passing 400 cfs through 21 feet of head producing a total installed capacity of 1050 kw. This average annual energy production is estimated to be 4,450,000 kwh. The total capital costs of the selected Jackson Mills alternative are estimated to be $1.84 million and the annual operation and maintenance costs are estimated to be $28,200. Revenue from the sale of electricity is estimated to be $218,000 annually. Using a 6% discount rate, the benefit/cost ratio for the selected alternative is 1.45.

At Mine Falls, a total of nine alternatives were considered. The recommended plan requires the renovation of the existing gatehouse and restoration of the adjoining canal system to a location approximately one mile downstream of the dam. At this point, approximately 0.15 miles west of the F. E. Everett Turnpike, flow will be diverted from the canal to the Nashua River through the generating equipment. This plan will require the construction of an inlet facility, penstock and powerhouse. Two horizontal shaft axial-flow turbines, each capable of passing 300 cfs at 32 feet of head, will produce a total installed capacity of 1260 kilowatts. Average annual energy production is estimated to be 7,200,000 kwh. The total capital costs are estimated to be $3.36 million and annual operation and maintenance costs are estimated at $45,000. Revenue from the sale of electricity is estimated to be $288,800 annually. Using a 6% discount rate, the benefit/cost ratio for the selected alternative is 1.08.

It is concluded that generating power at Jackson Mills and Mine Falls Dams is feasible and should be investigated further in a more detailed study.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (Continued)

TABLES

FIGURES

1.0 INTRODUCTION

1.1 Scope of Study

1.1.1 This study has investigated preliminary engineering and financial feasibility of the possible reinstallation of hydroelectric power production at Jackson Mills and Mine Falls Dam on the Nashua River in Nashua, New Hampshire. A Final Reconnaissance Study is expected to commence in July and finish in December of this year.

1.1.2 Alternative systems, sites, markets, and finances were evaluated to select the most desireable and financially feasible system. The evaluation of financial feasibility was based on (a) hydrologic and hydraulic characteristics of the Nashua River and the dam sites: and (b) the market value of generated power. The results of the foregoing analyses served as the primary bases for comparison of alternatives and ultimate selection of the recommended plan.

1.2 Authority

1.2.1 The authority for this study is contained in a resolution by the United States Senate Committee on Environmental and Public Works of 6 December 1978 at the request of Senator John A. Durkin of New Hampshire. A copy of this resolution is attached hereto in Appendix A.

1.3 Sources of Information

1.3.1 This report was prepared by Anderson-Nichols and Company, Inc. and the Corps of Engineers, New England Division under Contract DACW33-78-C-0345 Work Order No. 4. Anderson-Nichols provided the descriptions, background, marketing, engineering, financial, legal and regulatory aspects of this report along with all plates, figures, and tables. The Corps of Engineers provided the Vicinity Map and environmental analysis (Section 4.0).

1.3.2 Information was obtained from Federal agencies including: the Corps of Engineers, the U.S. Geological Survey, the Federal Insurance Administration, and the Federal Energy Regulatory Commission. At the state and local level, source information was compiled from the New Hampshire Water Resources Board, Water Supply and Pollution Control Commission, Department of Resources and Economic Development, Fish & Game Department, the Governor's Council on Energy, the Public Utilities

Commission, the Nashua Mayor's office, Assessor's office and Planning Board. Non-government sources including the Public Service Company of New Hampshire, Merrimack Valley Textile Museum, James River-Pepperell Inc. and the Energy Law Institute at the Franklin Pierce Law Center provided useful input information to this study. Their cooperation facilitated the successful completion of this assignment, and is gratefully acknowledged and appreciated.

1.4 Recommendations

1.4.1 The analyses conclude that Jackson Mills and Mine Falls Dams warrant more comprehensive investigations of hydroelectric feasibility.

1.4.2 The analyses were based on general estimates of costs and power production, and it is believed that development at both sites, contingent upon reasonable mitigation of potential problems described in greater detail in ensuing sections of this report, would be financially viable.

1.4.3 The scope of work of this Preliminary Reconnaissance Study precluded an extensive investigation of establishing a local power grid reinforced by Public Service Company at the sites which might have yielded greater revenue and provided a more favorable financial outlook. This aspect should be reviewed in a more detailed study.

1.4.4 The final recommendation is that the City of Nashua obtain Federal Energy Regulatory Commission license investigation permits, as provided by law, to establish their right to further study both Jackson Mills and Mine Falls Dam sites without any claim by another agency or individual.

2.0 DESCRIPTION OF EXISTING FACILITIES AND BACKGROUND

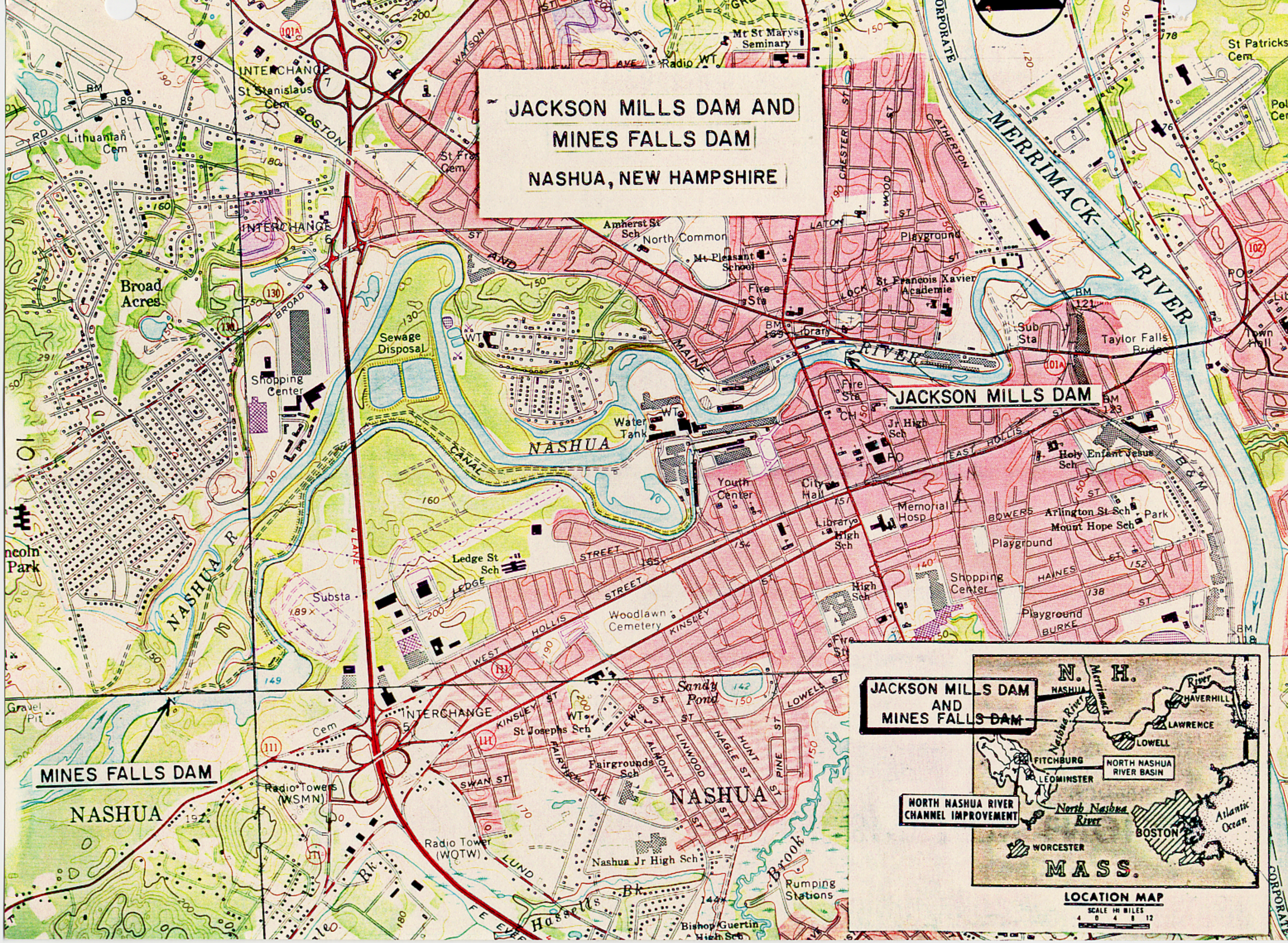
2.1 Description of Sites and Facilities

2.1.1 Jackson Mills Dam

2.1.1.1 Jackson Mills Dam is situated in the Nashua River in Nashua, New Hampshire, approximately 700 feet downstream from the crossing of U.S. Route 3 (Main Street) over the Nashua River. The river flows in an easterly direction at the dam, which is 1.3 miles above the confluence of the Nashua River with the Merrimack River. The dam is accessible from Route 101A which intersects Route 3 just north of the Nashua River. The site is shown on the Vicinity Map (Figure 1) and is presented in greater detail on Plate 5 in Appendix E.

2.1.1.2 Jackson Mills and appurtenances consist of a gravity-type structure, with a 2-foot wide flat overflow spillway section which is ungated. The dam was completed in 1920 and was built to generate power for the Jackson Mills. The crest elevation is 115.6 feet (MSL) with a crest length of 180 feet. The abutments consist of concrete-faced stone gravity structures, each about 65 feet in length, with top elevation approximately 11 feet above the overflow spillway crest. Near the northerly abutment is a forebay approximately 65 feet in length. The former generating plant is about 121.5 feet in length and 36 feet wide. The generating plant once housed three turbine bays each containing four timber sluice gates approximately seven feet square, and a 15" X 24" pressure relief gate. These sluice and pressure relief gates are presently inoperable. Two other outlet works are situated in the upstream face of one of the forebays. One is a timber waste gate of undetermined size and the other is a 3.3' X 8' wide ice chute. In addition, available records indicate the existence of an operable 30-inch pipe through the northerly bank concrete-faced stone masonry wall supplying Sanders Associates with water for back-up fire protection. The total height of the dam is approximately 33 feet and the total hydraulic head is 21 feet.

2.1.1.3 The dam is owned by Hi Tension Realty, a division of Sanders Associates of Nashua. The dam serves to maintain the water level for Sanders Associates and Nashua Corporation fire protection requirements. No operation or maintenance of the dam is presently being performed.


JACKSON MILLS DAM AND
MINES FALLS DAM
NASHUA, NEW HAMPSHIRE
JACKSON MILLS DAM
MINES FALLS DAM
NASHUA
MERRIMACK RIVER
NASHUA RIVER
N. H.
JACKSON MILLS DAM AND MINES FALLS DAM
NORTH NASHUA RIVER BASIN
NORTH NASHUA RIVER CHANNEL IMPROVEMENT
MASS.
LOCATION MAP

2.1.1.4 The Phase I Inspection and Evaluation Report of non-Federal dams prepared for the Corps of Engineers by Goldberg, Zoino, Dunnicliff & Associates, Inc. under Contract No. DACW33-79-C-0013 in February 1979 has determined the dam to be in fair condition. It has been recommended that the waste gate and ice chute be rehabilitated to operable condition to allow for some flow control during periods of peak flow. Rehabilitation of the sluice gates may not be practical because of a new restaurant operation located in the old powerhouse. Recommended remedial operations include repair of the south abutment, removal and relaying of slope revetment on the downstream south bank, repair of the north abutment, and repair of the north wall in the forebay (Reference 1).

2.1.2 Mine Falls Dam

2.1.2.1 Mine Falls Dam in the Nashua River is situated approximately 5.3 miles upstream from the confluence of the Merrimack and Nashua Rivers, 1.3 miles upstream of the F.E. Everett Turnpike crossing of the Nashua River and 4.0 miles above Jackson Mills Dam. The river flows easterly at this dam site. The dam is accessible by dirt roads from Mine Falls Park or from Route 111 (West Hollis St.) in Nashua. The site is shown on the Vicinity Map (Figure 1).

2.1.2.2 Mine Falls Dam was constructed in 1928 to replace an earlier structure which was washed out in the 1927 flood. The original dam and the canal system were built around 1820. Flow was diverted through the gatehouse into the canal for the purpose of generating power at the mill complex at the downstream terminus of the canal, 2.7 miles below the dam (See Plates 7, 8, and 9 in Appendix E).

2.1.2.3 Mine Falls Dam and appurtenances consist of a stone masonry, gravity-type structure 325 feet in length with a stone masonry spillway crest. The crest elevation is a 154.9 feet (MSL) with a crest length of 145 feet. The south abutment consists of cemented stone masonry with a concrete cap and is about 22 feet long. A plugged 2.5' X 2.0' flume penetrated the stone masonry. The south "backward J" training wall has a total length of 125 feet and leads to the gatehouse. The dam is approximately 24 feet in height. The outlet works consist of five wooden gates approximately six feet wide by 9.5 feet high. Four of the five gates are inoperable with three prefabricated concrete blocks bolted in place. The fifth gate controls releases into the canal and mill pond.

The outlet invert is at elevation 141 (MSL) and is currently maintained in fully opened position. There is a head loss of approximately 6 feet through the gatehouse and there exists a difference in water surface elevation of approximately 32 feet between the canal and the Nashua River.

2.1.2.4 The Phase I Inspection Report prepared for the Corps of Engineers by Goldberg, Zoino, Dunnicliff and Associates, Inc. under Contract No. DACW33-79-C-0013 in March 1979 has determined that the dam is in fair condition. It has been recommended that the following measures be taken at the dam: reconstruct the north canal wall on a competent foundation, repair cracks in the north end wall of the dam, and perform a technical inspection of the dam annually.

2.1.2.5 The dam is owned by the City of Nashua and inspected at frequent, though irregular, intervals by the Nashua Department of Parks and Recreation. No operation of the dam is performed and no formal maintenance program exists (Reference 2).

2.2 General Description of Water Rights

2.2.1 In New Hampshire, a developer of hydroelectric power, in acquiring his stream-bordering land, has also acquired certain riparian rights for usage of the water. These rights are outlined by the common law riparian doctrine of reasonable use. The ownership of the land bordering the stream gives a developer the right to use the water but not ownership of the water. Every owner of land situated adjacent to a stream who has not sold his water rights, has the right to the natural flow of the stream and to insist that the stream shall continue to run, that it shall flow off his land in its usual quantity, at its natural place and usual height and that it shall flow off his land upon the land below in its accustomed place and at its usual level (Reference 3).

2.3 Abutting Land Use

2.3.1 The land use and apparent ownership of abutting properties were obtained from the tax maps and inventory card file available in the Nashua Assessor's Office. The information is presented on Plates 1 and 2 (Appendix E).

2.4 River Basin and Hydrology

2.4.1 The Nashua River Basin encompasses 529 square miles within the states of Massachusetts and New Hampshire. Portions of the following counties are included: Worcester and Middlesex Counties, Massachusetts and Hillsborough County, New Hampshire. The Nashua River is a major tributary of the Merrimack River, one of several New England rivers east of the Connecticut River Basin draining to the North Atlantic. The Nashua River has two principal branches: the south or main branch originating north of Worcester at the Wachusett Reservoir Dam and the north branch formed by the junction of the Whitman River and Flag Brook in West Fitchburg. The two branches join at Lancaster Common and flow north to the Merrimack River at Nashua, New Hampshire.

2.4.2 In a hydrologic sense, Wachusett Reservoir effectively diverts the 115 square mile portion of the basin which drains to this upstream impoundment. The Wachusett Reservoir is part of the Metropolitan District Commission water supply system and is used to store and divert to the Boston area water conveyed by aqueduct from the Quabbin Reservoir and from the sub-watershed contributing drainage directly to Wachusett Reservoir. A prescribed rate of flow is released from the reservoir to the Nashua River (Reference 4).

2.4.3 A U.S. Geological Survey (USGS) gaging station (No. 01096500) with a net drainage area of 316 square miles is located on the Nashua River at East Pepperell, Massachusetts. Daily discharges, reflecting regulated flow by an upstream impoundment (James River - Pepperell Company), have been recorded continuously since 1935. The average daily flow has been 527 cubic feet per second (cfs) for the 42-year period of record (1936-1977). Flows are usually highest in March, April, and May during spring snowmelt and are considerably lower in July, August, and September. A flow-duration curve has been compiled for the Nashua River from gage date (1936-1977) and is presented in Figure 2. The four other flow-duration curves presented in Figure 2 have been developed for the wettest and dryest years on record, 1956 and 1965 respectively, and the months of April and September for the period 1936-1971. These curves show the greater seasonal and annual variations in flow.

NASHUA RIVER HYDROLOGY

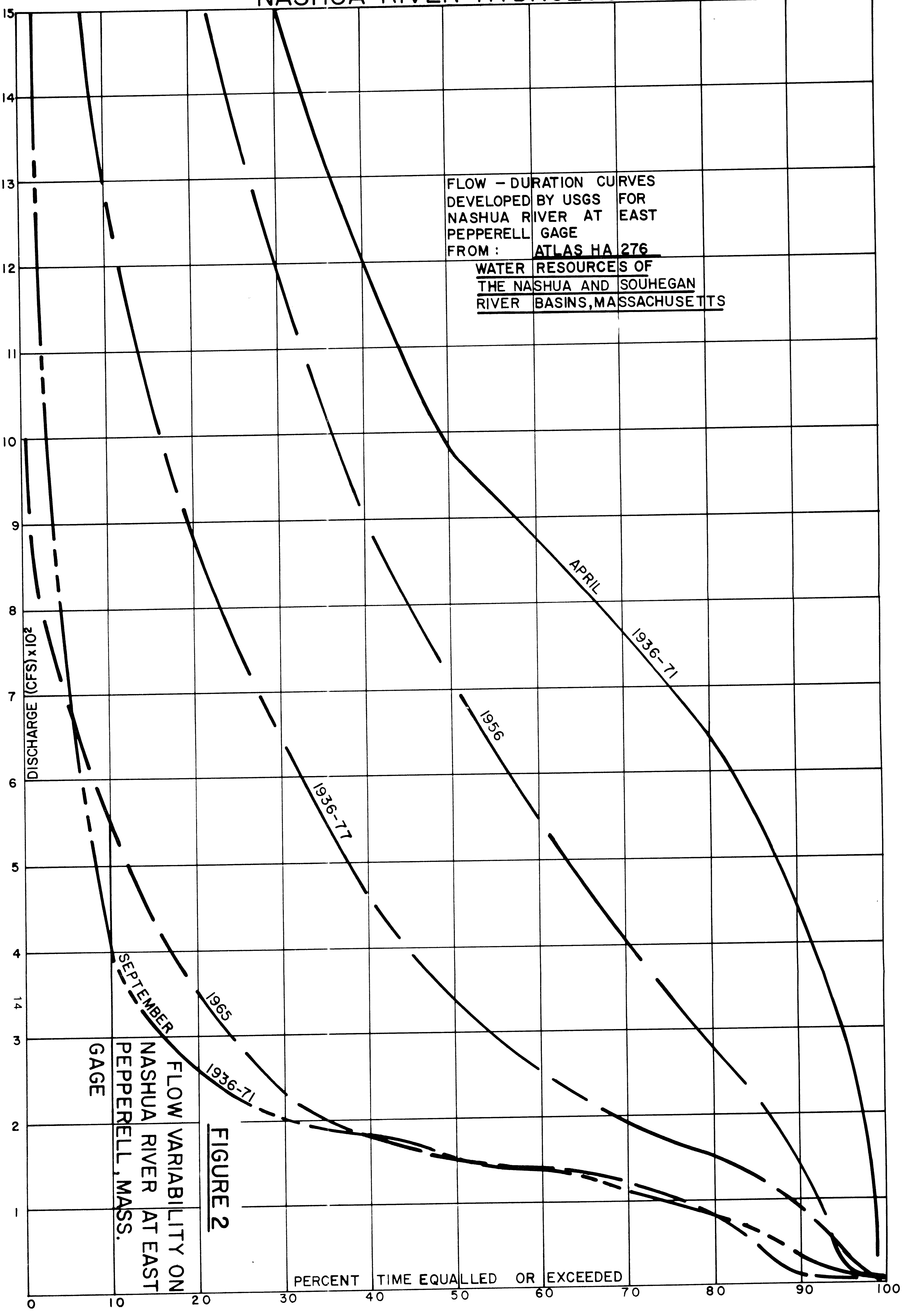


FIGURE 2
FLOW VARIABILITY ON NASHUA RIVER AT EAST PEPPERELL, MASS. GAGE

2.4.4 Because the study sites are located considerably downstream of the gaging station, development of a flow-duration curve which included the additional drainage area (89 square miles) between the gage and the study sites was required. Although a small increase in drainage area exists between Mine Falls Dam and Jackson Mills Dam, the effective drainage area of both dam sites were assumed to be essentially the same. A flow duration curve was developed for the Nissitissit River which empties into the Nashua River 0.8 miles below the East Pepperell gage. The Nissitissit River is the only large tributary of the Nashua River between the gage and the study sites comprising significant additional drainage area, and curves for the two locations were judged to be additive. Using a regression equation developed by S.L. Dingman (Reference 5) based upon drainage area and mean basin elevation, the flow-duration data for the Nissitissit River were developed. These data are presented in Appendix B. The flow value equalled or exceeded 95 percent of the time agrees closely with a USGS estimate for the Nissitissit River (Reference 6). The composite flow-duration curve developed for the Nashua River at Mine Falls Dam is presented in Figure 3.

2.4.5 The foregoing flow analysis excludes consideration of flow maintenance required by the recently revised NPDES provisions for the river at the James River - Pepperell Company just upstream of the USGS gage at East Pepperell, Massachusetts. According to the Company's NPDES permit, effective until February 1982, the James River - Pepperell Company is required to pass a minimum of 60 cfs or a flow equal to the natural flow into Pepperell Pond. Prior to 1977, their operation was required to pass approximately 15 cfs. Thus, it is possible that the low-flow portion of the composite flow-duration curve will change; although without more data, it is not possible to reliably quantify how significant the change would be for the purpose of estimating hydropower.

2.5 Other Pertinent Information

2.5.1 Consideration of Program Rules and Regulations for development of lands purchased with funds from the Heritage Conservation and Recreation Service (U.S. Department of Interior) must be made as Mine Falls Park was purchased and Jackson Mills Dam would be purchased using such funding. These regulations require the purchase of land of like dollar value and recreational significance to replace any land removed from recreational use (Reference 7). This cost should be investigated in greater detail during ensuing Feasibility Analyses as

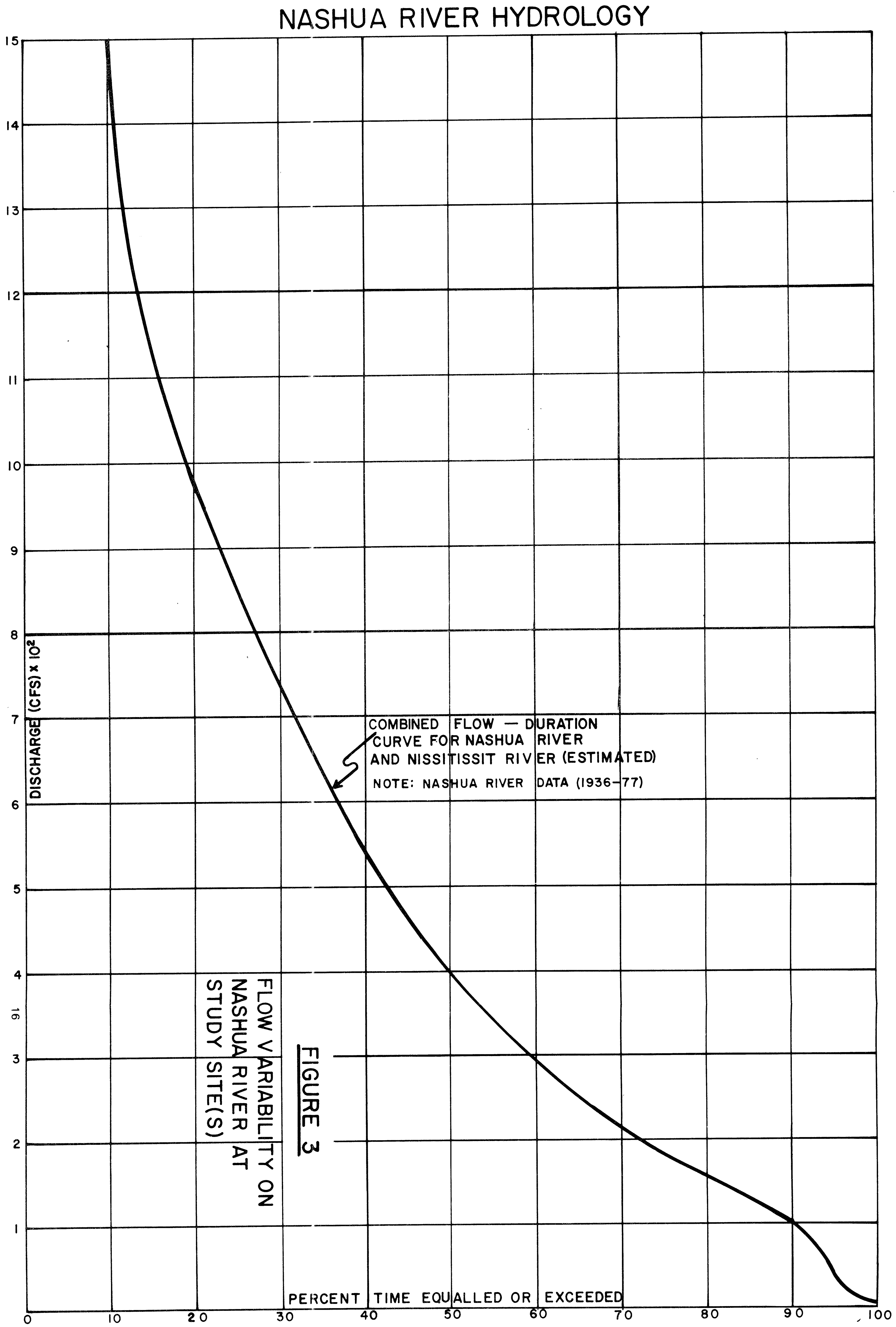


FIGURE 3

FLOW VARIABILITY ON NASHUA RIVER AT STUDY SITE(S) costs could not be accurately determined during this Preliminary Reconnaissance Study.

2.5.2 Jackson Mills Dam is highly visible in the downtown area. Careful consideration must be given to aesthetically landscape and design any structural changes to complement the architecture and scenery of the redeveloping area.

2.5.3 Restoration of the Mine Falls Dam for hydropower redevelopment must incorporate provisions to minimize any temporary or permanent disturbance to the park; therefore, the architecture and landscaping must be conceptually compatible and in harmony with the park atmosphere. The gatehouse and dam area have both historical and archaeological significance (See Section 4.0) which must also be preserved. Mine Falls Park is intended to be a recreational area providing boating, swimming, natural habitat and environs and, although discouraged but not precluded, snowmobile usage during the winter snow season. For these reasons the water level and flow through the pond and canal must be maintained at a desirable level to promote and encourage a majority of these activities.

2.5.4 Both Mine Falls and Jackson Mills sites have strong potential educational value due to their proximity to schools and the Nashua Public Library. The powerhouses of the facilities are planned to provide viewing galleries with displays explaining salient facts about hydropower generation, its potential and limitations, energy concepts and conservation, historical points of interest at the sites and simplistic general powerhouse descriptions. Jackson Mills Dam has the possibility of additional educational value if the site is developed for a solar and wood demonstration project proposed by Sanders Associates.

3.0 MARKETING, FINANCING, AND MANAGING HYDROPOWER ENERGY

3.1 Establishing a Potential Market

3.1.1 Four possible plans are identified for use of energy produced at the proposed hydroelectric sites in Nashua.

3.1.2 The first would require the presence, on the site, of an industrial customer whose electrical energy requirements would closely match the output of the proposed hydroelectric sites. For a peaking plant it is difficult to envision any suitable industry whose operation would match the pond storage cycle. If solely dependent upon the energy output of a run-of-the-river installation, the industrial user's operations would have to be virtually stopped during the dry months to avoid the purchase of public utility energy and absorption of demand charges, which might make the overall project uneconomic.

3.1.3 The second possible plan for use of energy from the proposed hydroelectric sites would be a special usage entailing the production of a commodity whose manufacture could match closely the production of energy from the plant(s). A typical example would be the electrolytic production of an industrial gas such as hydrogen.

3.1.4 A third option would involve installing a separate independent grid from the sites to distribute energy to the various municipal buildings in reasonable proximity to the sites, to traffic signalization, or street illumination. The grid system would require a tie-in to an existing substation served by the Public Service Company of New Hampshire. This grid would be a single meter system, whereby at times of peak hydroelectric power output, the system would supply designated city facilities and sell the surplus to the Public Service Company. At times of low hydroelectric power production, the grid would be supplied power from the Public Service Company through the substation and be metered for the usage. This alternative of power production will require installing new distribution lines and removing the direct connections from the city facilities to the existing power grid. The facilities which could be included in this plan are the Nashua Public Library, City Fire Station, Ledge Street School, Nashua Public Works Garage, Nashua Police Department, Nashua High School, Amherst Street School and nearby traffic signals and street lights. At present this marketing arrangement is inconsistent with New Hampshire legislation.

3.1.5 The fourth plan for use of energy produced by the proposed hydroelectric sites is the sale of the total power output directly to the utility company. A recent order by the Public Utilities Commission of New Hampshire on April 18, 1979 requires that the franchised utility shall buy the entire output of small hydro plants (such as those proposed herein for redevelopment on the Nashua River) and shall pay for such energy the sum of 4.0 cents/kwh for the output of a "run-of-the-river" plant (Reference 8).

3.1.6 The fourth marketing option would appear to be the best overall, since events in the State of New Hampshire are moving toward the stimulus of low-head hydropower production. The simple concept of selling generated hydropower to the Public Service Company through a single or possibly two metered points, one for each generating site, provides a readily obtainable revenue source for the generated hydropower and a market which can use the total energy generated.

3.1.7 Events within the purview of this project could lead to another piece of legislation which would mandate the public utilities to "wheel" or distribute the power produced by such independently developed hydroelectric units from its source to any power user in the public utility grid system, with a reasonable prerequisite wheeling charge by the utility (See Appendix A). In Nashua's situation this would mean that the power produced at the Mine Falls and Jackson Mills plants could be wheeled, for example, to City Hall, the schools in the area, Ledge Street and Amherst Schools, the Fire Department, the Library or any city building which has a meter. No additional distribution lines would be required. In essence, the local hydropower produced with the addition of a relatively minor wheeling charge, would replace the power Nashua would normally purchase from the Public Service Company at a rate of approximately 6¢/kwh or more, depending on the prevailing rate structure. Consequently, there would be an offsetting of kilowatt hours; power produced and power used would cancel, less the wheeling charge, which Nashua would have to pay.

3.2 Financing

3.2.1 The financial scenario developed for these sites assumed that the City of Nashua would provide the funding to redevelop the hydropower generation through 20-year bonds bearing an interest rate of approximately 6%, serviced with a sinking fund established for the life of the bond issue. A sensitivity analysis was performed in the financial feasibility assessment to develop a range of comparative values using different rates of interest.

3.2.2 The use of tax-exempt bonding for hydropower development could raise objections from the public utility sector such as Public Service Company and other energy producers if competition for markets develops.

3.2.3 The ownership of these sites by the City of Nashua, with its non-profit status, raises the question as to the possibility of a problem with the need to seek prior clarification or interpretation from the Internal Revenue Service - since any income resulting from the production of hydropower might be taxable. This tax aspect is construed to be not within the scope of the Preliminary Reconnaissance Study but should be investigated in a detailed reconnaissance study.

3.3 Management

3.3.1 It was assumed that the City of Nashua would manage the sites, providing the on-site inspection, daily cleaning, and maintenance of the trash racks and equipment; and that the operational control of the hydropower generating facilities would be fully automatic. There would be no manned control room to monitor the functioning of the system. Emergency shutdown mechanisms would be provided for the safety and protection of the automatic equipment. Provisions would be incorporated to assure that any technical or mechanical maintenance would be performed by a technician provided by the manufacturer of the equipment, or under a service-type policy providing a specialist highly trained to service the equipment. Nashua should not be expected to provide these maintenance, troubleshooting or repair type services.

4.0 ENVIRONMENTAL CONSIDERATIONS

4.1 Environmental Setting

4.1.1 General

4.1.1.1 The Nashua River watershed included 34 communities in Massachusetts and New Hampshire. The river is 57 miles long with the South Branch flowing from the Wachusett Reservoir in West Boylston, where it continues south to Lancaster, Mass. Here it joins the North Branch, forming the main stem, and changes to a northerly flow to Nashua, N.H. and ultimately flows into the Merrimack River. The river bank is basically undeveloped, and for three-fourths of its length it flows through country consisting of fields, wetlands, and forests.[I]

4.1.2 Topography

4.1.2.1 The basin has a total drainage area of 529 square miles, with 88 square miles being in New Hampshire, and 441 square miles in Massachusetts.

4.1.2.2 The gradient of the river is gentle, with the main stem dropping 105 feet from Lancaster to the Merrimack River 35 miles downstream. The relief varies, with gentle slopes and low hills on the eastern side of the main stem valley, with steeper topography on the high-land edge on the west.[II] The highest peak in the watershed is Mt. Washusett, with an elevation of 2006 (MSL).

4.1.3 Geology

4.1.3.1 The bedrock of the Nashua River water-shed is mostly granite, and is covered with a mantle of soils, sand, gravel, and rock which was placed as glacial drift or as interglacial deposits. The basin is underlain by quartzites and schists which were metamorphosed during the collision of the North American and European plates in the Early Paleozoic period, causing the general north-south orientation of the basin.[III]

[I] The Nashua River Canoe Guide, Charles D. Harris, July 1976.

[II] Plan for the Nashua River Watershed, Nashua River Watershed Association, 1972.

[III] The Nashua River Canoe Guide, Charles D. Harris, July 1976.

4.1.3.2 A wide variety of soils are present in the watershed and include clay, peat, and deep sandy loams. Most of the river has between 6 and 8 feet of sludge covering the bottom.

4.1.4 Water Quality

4.1.4.1 The entire length of the Nashua River in New Hampshire has been assigned an objective water quality standard of Class C by the New Hampshire Water Supply and Pollution Control Commission. Class C waters are suitable for boating, fishing and industrial water supply. Present water quality conditions in the river, however, do not meet the required criteria for Class C waters. Based upon data collected by the State of New Hampshire in 1977 and 1978 four miles upstream from Mine Falls Dam at Hollis, New Hampshire, high concentrations of total coliform bacteria and phosphorus are primarily responsible for the degradation. No data is available for the immediate area around Mine Falls and Jackson Mills Dams. The bacterial contamination is of both human and animal origins probably emanating from non-point sources and urban runoff. Concentrations of nitrogen and phosphorus are very high, and biological response is active with chlorophyl "A" levels typically about 30 mg/M^3 and as high as 150 mg/M^3. Daytime dissolved oxygen levels are always above 6 mg/l; pH varies within 0.5 units of neutrality; and suspended solids range up to 15 mg/l.

4.1.4.2 In support of the development of a water quality management plan for the Nashua River Basin, sediment sampling and analysis was performed in 1973 by Camp Dresser & McKee, Inc. at two sites behind Jackson Mills Dam. This survey revealed the existence of two types of PCB's, dieldrin, DDT and trace metals including aluminum, chromium, copper, mercury, lead and zinc in the sediments. The chlorinated hydrocarbons are very insoluble in water, with saturation concentrations of 1 to 2 ppb, and toxic concentrations were not expected to exist in the water. The trace metals concentrations in the sediments were not expected to induce toxic conditions in the water column even under extreme conditions of metals release.

4.1.5 Climatology

4.1.5.1 The Nashua River watershed lies between 42^o and 43^o north latitudes with prevailing west to east winds, and northerly and southerly movements of tropical and polar air storm systems moving from west to east cause local variations in temperature and precipitation.

4.1.5.2 Normal annual precipitation at Nashua, N.H. is 39.8 inches. The mean winter temperature is 25.3° F., normal July temperature is 67.9° F. Average annual snowfall is 66.5 inches.[IV]

4.1.6 Cultural Resources

4.1.6.1 The records of the State Historic Preservation Officer contain no direct references to prehistoric archaeological resources within the proposed project area. However, unconfirmed historical references exist for prehistoric occupation in the vicinity of Mine Falls Dam, while drainage, slope, and other environmental conditions indicate high potential for existence of prehistoric cultural resources within any undisturbed areas near the river.

4.1.6.2 Historic period resources in the area include the Mine Falls canal and mill complex at its terminus, both begun in the 1820's, with appurtenant structures such as the old emergency spillway, the 1888 gatehouse, and dam within the Mine Falls project area. Historic period resources within the Jackson Mills area include the 1919 dam and power plant on the south bank and filled foundation remains of unknown use on the north bank of the river. Disturbance of the north bank and the modifications and late date of the 1919 power plant may limit the historic value of features in the Jackson Mills project area.

4.1.6.3 Any alternatives involving land modification would require a cultural resource reconnaissance of presently undisturbed areas during the next planning phase.

4.1.6.4 Assessment of the architectural and historic engineering value of structures and remaining machinery at both Mine Falls and Jackson Mills project areas will be needed if alternatives involving modification of these features are considered in further project planning.

4.1.7 Aquatic Ecosystem

4.1.7.1 The nearest Great Ponds (more than 10 acres) in the study area are in Hollis, N.H., approximately

[IV] Plan for the Nashua River Watershed, Nashua River Watershed Association, 1972.

8 miles south of Nashua. They are: 1. Flints Pond, 48 acres in size and private with no access or use; and 2. Rocky Pond, 46 acres in size and also private with no access or use.

4.1.7.2 According to the Nashua River Watershed Association, the only areas in the watershed where gamefish are found are in the Nissitissit and Squannacook Rivers which are tributaries of the Nashua River, and are located south of Nashua, N.H. in Pepperell and Townsend, Mass., respectively. Rainbow trout, brook trout, brown trout, bass and pickerel are most commonly found in these rivers. However, these areas are a good distance from the dam sites and would not be affected by any of the alternative projects.

4.1.7.3 The area of the Nashua River which included Jackson Mills and Mine Falls has not been stocked with trout by the N.H. Fish and Game Department.

4.1.7.4 The following list of fish species supplied by the N.H. Fish and Game Dept. are those species which are presently inhabiting the Merrimack River Basin. Although it is not known whether all of these species are currently found in the Nashua River itself, this list presents a reasonable overview of what may inhabit the river at present or in the future as the river continues to be cleaned up. At present, the river is too polluted to support any kind of game fish.

4.1.8 <u>Terrestrial Ecosystem</u>

4.1.8.1 The watershed's vegetative cover is primarily second-growth mixed hardwood/softwood forests. White pine, red pine and hemlock are common. Species of hardwood include red maple, silver maple, white oak, willows, slippery elm, and birches. In summary, between 70 and 75 percent of the total area of the watershed are forests and primarily wooded land.

4.1.8.2 Common shrubs found along the streamsides and in the wetlands are: button bush, sweet viburnum, witch hazel, blueberry, alders and sumac. Marsh lady slippers are also common.

4.1.8.3 Raccoon, woodchuck, otter and beaver are found along the river bank where development is not heavy. Mammals present in the wooded areas also include chipmunks, squirrels, mice, foxes and shrews. Mallards and black ducks are common waterfowl species which can be found in Mine Falls Pond immediately upstream from Mine Falls Dam.

Common name	Scientific name
Atlantic Salmon	Salmo salar
Landlocked Salmon	Salmo salar
Brown Trout	Salmo trutta
Brook Trout	Salvelinus fontinalis
Rainbow Trout	Salmo gairdneri
Lake Trout	Salvelinus namaycush
Chain Pickerel	Esox niger
Redfin Pickerel	Esox americanus
Yellow Perch	Perca flavescens
Smallmouth Bass	Micropterus dolomieui
Largemouth Bass	Micropterus salmoides
Walleye	Stizostedium vitreum
Black Crappie	Pomoxis nigromaculatus
Pumpkinseed	Lepomis gibbosus
Redbreast Sunfish	Lepomis auritus
Bluegill	Lepomis macrochirus
Banded Sunfish	Enneacanthus obesus
White Perch	Morone americana
Yellow Bullhead	Ictalurus natalis
Brown Bullhead	Ictalurus nebulosus
White Catfish	Ictalurus catus
American Eel	Anquilla rostrata
White Sucker	Catostomus commersoni
Longnose Sucker	Catostomus catostomus
Golden Shiner	Notemigonus crysoleucas
Redfin Shiner	Notropis umbratillis
Spottail Shiner	Notropis hudsonius
Common Shiner	Notropis cornutus
Bridle Shiner	Notropis bifrenatus
Swamp Darter	Etheostoma fusiforme
Fall Fish	Semotilus corporalis
Blacknose Dace	Rhinichthys atratulus
Longnose Dace	Rhinichthys cataractae
Eastern Madtom	Notorus sp.
Barbot	Lota lota
Creek Chubsucker	Erimyzon oblongus
Creek Chub	Semotilus atromaculatus
Lake Chub	Couesins plumbeus
Slimy Sculpin	Cottus cognatus
Goldfish	Carassius auratus
Carp	Cyprinus carpio

4.1.9 Rare and Endangered Species

4.1.9.1 The following plant species have been reported to be present at stations in Nashua, N.H. They are considered rare by the New England Botanical Club as reported in the 1978 publication from the NEBC entitled: "Rare and Endangered Vascular Plant Species in New Hampshire." Should this project be carried through to the final planning stages, the presence of these plants will be studied in subsequent investigations. It should be noted that at present, none of these are on the Federal list of endangered plants for this area.

Zizania aquatica L. var. angustifolia Hitche - wildrice
Allivor canadinsi L. - wild garlic
Prunus americana Marsh. - American plum
Tephrosia virginiana L. Pers. - Goat's - Rue
Xanthoxylum americanum Miller - Northern Prickly - Ash
Viola pedata L. var. Lineariloba DC. - Birdfoot violet

4.1.9.2 No rare and/or endangered faunal species are known to exist in the vicinity of Jackson Mills and Mine Falls.

4.2 Environmental Considerations of the Proposed Alternatives.

4.2.1 Jackson Mills

4.2.1.1 Alternative #1 - Renovate existing powerhouse facilities in the restaurant.

4.2.1.1.1 Jackson Mills is located in the center of Nashua, N.H., therefore, no environmental effects will be associated with this alternative. A minimal increase in turbidity of the water surrounding the restaurant, most likely in the pond above the dam, could result from any construction activities. As these waters are very polluted, there are no important fisheries that would be impacted. There is no vegetation on this side of the river which would be affected by construction activities.

4.2.1.2 Alternative #2 - Construct powerhouse on south river bank.

4.2.1.2.1 The bank on the south side slopes steeply down to the river, with small bushes and saplings scattered over the bank. Sumac is common along here. On top of the bank, and adjacent to the Nashua Public Library, the ground has been landscaped, and ornamental cherry trees have been planted. Should this alternative be selected, construction activities would necessitate the removal of these trees. Impacts on the brush along the bank are minimal as these species adapt quickly to any changes, and would start to re-establish in the area soon after construction activities are finished.

4.2.1.2.2 Turbidity would increase on the downstream side of the dam for the duration of construction.

4.2.1.3 <u>Alternative #3 - Construct powerhouse over or on the dam</u>.

4.2.1.3.1 Impacts associated with this alternative would be mainly on the river itself. Increased turbidity above and below the dam site would be the major effect. Vegetation on the banks would be removed on any access ways made by construction equipment. However, this vegetation would again quickly re-establish itself after construction is completed. As with Alternative #1, there are no important fisheries existing in the area that would be affected by the siltation or turbidity.

4.2.2 <u>Mine Falls</u>

4.2.2.1 <u>Alternative #1 - Locating powerhouse in the vicinity of existing gatehouse and dam, with a possibility of raising the dam 3'.0</u>.

4.2.2.1.1 Mine Falls is located in a wooded area 3 miles upstream from Jackson Mills. This area is considered to be aesthetically pleasing, with tall white pines on the banks on either side of the river. Water fowl are frequently seen on Mine Falls Pond, and are mainly mallards and black ducks, and occasional gulls that have travelled in from the coast.

4.2.2.1.2 Should a powerhouse be constructed at this site, it would necessitate removing some trees, mostly white pine.

4.2.2.1.3 There is presently an access road leading down to the gatehouse which would probably be used during construction. Any small mammals that would normally go to the pond and river to feed would be kept away by noice created from construction activities. This would also include waterfowl. However, this impact would occur only for the duration of construction.

4.2.2.1.4 Should the dam be raised 3 feet, this would impact the surrounding shoreland permanently. The small islands that are now present which are utilized by waterfowl for resting and feeding would be inundated. Though the banks of the pond are somewhat steep, they slope gradually at the base, then steeply upwards. This base would be inundated, covering the existing vegetation. White and red pines would be impounded, and also small stands of maple and birch. Debris would also be a problem after the initial raising of the pool.

4.2.2.1.5 In summary, raising the dam and pool elevation 3'0 would have a moderate to severe impact on the shoreline vegetation and wildlife at the Mine Falls Dam site.

4.2.2.2 <u>Alternative #2 - Locating powerhouse about one mile downstream, utilizing a penstock between the canal and the powerhouse near the river</u>.

4.2.2.2.1 The impacts associated with this alternative are those concerned with the terrestrial environment. The site where the penstock would be placed between the canal and the river contains dense stands of white pine, with scatterings of hardwoods. An opening would have to be cut in order to accommodate the penstock, which would necessitate the removal of some of the existing pine stands in that location.

4.2.2.2.2 There would be a temporary disruption in any resident wildlife populations near the area due to noise and physical construction activities.

4.2.2.2.3 The placement of a powerhouse near the river would also disrupt the terrestrial environment. Cutting of trees for access and for the site and also temporary disruption and dislocation of resident wildlife would be impacts associated with the construction of the powerhouse.

4.2.2.2.4 As there are bicycle and walking paths in the area, the placement of a penstock and powerhouse in the area would adversely impact the aesthetics of this natural area.

4.2.2.3 <u>Alternative #3 - Rehabilitating former electric generating facilities at the end of the canal system</u>.

4.2.2.3.1 The generating facilities at the end of the canal are located in an industrial section of Nashua. Therefore, there would be no environmental impacts associated with this alternative.

5.0 ANALYSIS OF ALTERNATIVE GENERATING CAPACITIES

5.1 Hydraulic Turbine Configuration

5.1.1 Hydraulic turbines are categorized as: pressureless (impulse), pressure (reaction), propeller (a form of pressure turbine), and cross flow (a hybrid of impulse and reaction types). The impulse design has cost-effective operating characteristics for high heads (800 ft. and higher). The reaction design most often utilizes a Francis runner which operates at heads from 15 to 1100 feet. Cost-effective operation of this type of turbine requires a head of 100 feet or more. The propeller type (often Kaplan runner) is cost-effective at heads below 60 feet (Reference 9). The cross flow turbine will operate at heads from 15 to 550 feet, but the efficiency of the impulse aspect of its design configuration is maximized under high head and low flow conditions.

5.1.2 With the limited head (less than 40 feet) and wide seasonal variation in flow at the dam sites in Nashua, the most cost-effective unit would be the Kaplan type, variable pitch blade propeller turbine.

5.1.3 Installation of the Kaplan turbine can be vertical or horizontal; the choice most often depends on head available or the site configuration. A very low head application is more effective for the vertical configuration as the units are often of large diameter and low speed, allowing less excavation for the powerhouse. The horizontal configuration places the drive shaft in the line of the flow through the runner; therefore, the generator must be also within or around the draft tube, or the flow must be diverted between the runner and generator with the drive shaft penetrating the draft tube. The bulb type system has the generator inside a steel bulb with runner downstream. The entire unit is contained within the draft tube. The bulb unit requires more excavation than other applications and the flows available are at or below the lower limit of standard pre-designed units. Another application utilizes a generator around the draft tube with the stators connected to shafts through the turbine blades. The rim units are relatively untested and inordinately expensive for application at the available flows. The last application considered was the tube type, with the runner connected to the generator by a shaft penetrating the draft tube. It is available in standard pre-designed units for applications involving a wide range of flows and heads encompassing conditions encountered at the sites in Nashua.

5.2 Generator Selection

5.2.1 Generators are either synchronous or induction systems (See Plates 3 and 4, Appendix E). The synchronous generator produces its own excitation and controls its frequency and phase. This generator requires a sophisticated speed control mechanism to apply a proper blade torque from the turbine to the generator for the given load. An induction generator does not require speed control equipment; it requires outside excitation. In this application, the Public Service Company grid system would provide the necessary excitation through the substation connection. The induction unit would operate over a wide range of speeds; consequently neither the sophisticated speed control mechanism nor the excitation generator are required for power production. Planned operation of this system does not allow generation independent of the grid system; therefore, an induction generator would be recommended for cost reduction.

5.3 Unit Sizing

5.3.1 Table 1 summarizes the analyses for turbine configuration and sizing. It was assumed that the powerhouse would have only one or two units as the flow is too small to warrant additional construction and equipment costs for more units. Overall efficiency of the system was assumed to be 80% at Jackson Mills and 80% at Mine Falls. The lower limit of effective operation of the turbine-generator units is 50% of the design flow which is also deemed conservative as the manufacturers recommend 40% of design flow. The assumptions are conservative, but the large variation in flow and variations in head could reduce the overall effectiveness of the system from approximately 85% efficiency which the manufacturers specify. The use of conservative efficiencies and capital investment and operation and maintenance costs (described in following sections of this report) are consistent with the intent of this Preliminary Reconnaissance Study. It has also been assumed that in a multiple unit installation, all units will have variable blades, although a potential saving might be obtained if one unit is fixed blade and the other(s) variable (especially if twin units are used).

5.3.2 Unit sizes and hydraulic capacities are based on Allis-Chalmers sales literature as it is generally representative of all major manufacturers and was readily available. Plant factors and annual energy generation for each powerhouse were derived using graphical integration techniques applied to the drainage area-adjusted USGS flow-

TABLE 1
TURBINE UNIT SIZING

SITE	UNIT SIZE (mm)	AVERAGE HEAD (feet)	OPERABLE HYDRAULIC RANGE (cfs)	PLANT FACTOR	ANNUAL ENERGY GENERATED (kwh)
JACKSON MILLS					
	2000	21	800/400	0.571	4,384,000
	2250	21	985/500	0.578	4,444,000
	750/1750	21	755/60	0.660	5,072,000
	750/2000	21	925/60	0.707	5,434,000
	1000/1750	21	840/100	0.723	5,555,000
	1000/2000	21	1010/100	0.759	5,830,000
	1250/1500	21	790/160	0.686	5,274,000
	1250/1750	21	955/160	0.752	5,780,000
	1500/1500	21	930/230	0.709	5,447,000
MINE FALLS					
	1750	32	560/280	0.503	5,908,000
	750/1500	32	565/60	0.581	6,824,000
	750/1750	32	685/60	0.641	7,521,000
	1000/1250	32	525/105	0.567	6,660,000
	1000/1500	32	650/105	0.640	7,520,000
	1250/1250	32	630/160	0.615	7,221,000

duration curve for the Nashua River at the study sites (See Appendix B). Power computations were based on the classic formula, $P=\frac{EHQ}{11.8}$, where: P=power in kilowatts; E=turbine/generator efficiency; H=net head in feet; and Q=discharge in cubic feet per second. The annual energy generation was determined by integrating the area under the flow-duration curve and then converting the area into energy units.

5.3.3 The effect of incremental storage provided by flashboards on this project would smooth and simplify operation of the plant system and facilitate realization of the plant factors. Flashboards also provide increased hydraulic compatability of the dam sites by smoothing the irregularities of flow. For these reasons, appropriate heights of flashboards would be recommended for Mine Falls Dam and Jackson Mills Dam. Flashboards must be limited to an elevation not greater than the elevation at which over-bank flooding would occur. The river has such a flat slope that dredging of the tailrace areas to attain more head could not be justified.

5.3.4 Units with two turbines of unequal size allow for more efficient flow utilization and achieve higher plant factors. While equal-sized units permit slightly less efficient flow utilization, the analyses assume that they provide economies of design, maintenance, and operation which more than offset the incremental decrease in plant factor. Further in-depth investigations in the Final Reconnaissance Phase should be performed to verify these assumptions.

6.0 ALTERNATIVE SITE DESCRIPTION, SELECTION PROCESS AND RECOMMENDED CONCEPT

6.1 Jackson Mills Dam

6.1.1 The City of Nashua does not, at the time of this report preparation, own the dam, water rights, or existing powerhouse. The dam is owned by Sanders Associates through Hi Tension Realty. The former powerhouse is owned by a private individual who leases it to the Chart House Restaurant. The ownership of parts of the dam and appurtenances by separate parties poses a potential but not insurmountable problem for redevelopment of any hydropower facilities at this site. It was assumed for this analysis that ownership of the spillway, southern bank, abutment and water rights would be transferred to the City of Nashua and that ownership of the existing powerhouse will remain as it is at present. Any alternative which utilizes the existing powerhouse is contingent on an agreement with its owner relating to the use of facilities, desig features and construction methods. The Nashua River is presently a Class C river by state water quality standards. Although a Class C river should not have significant quantities of game fish, a fishway might be required in the future For purposes of this analysis, the provisions for or costs of a fishway are not included.

6.1.2 The Jackson Mills alternative hydropower generating sites were selected with the assumption that power production would be generated on or immediately adjacent to the existing dam and powerhouse (See Plate 5, Appendix E).

6.1.2.1 Alternative A would utilize the existing powerhouse and intake facilities by making minor modifications to the existing structure.

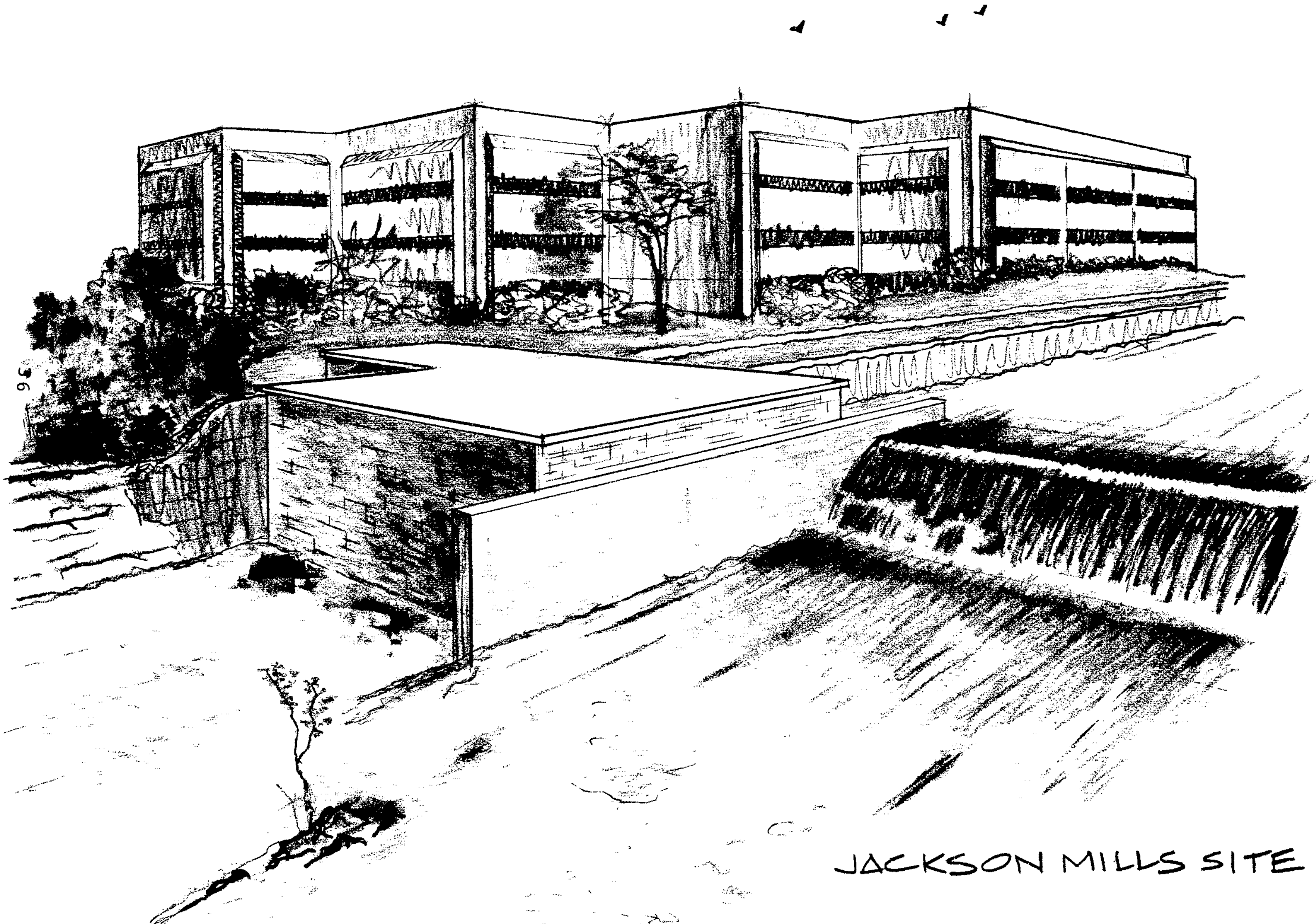
6.1.2.2 Alternative B would provide for construction of a new powerhouse located immediately adjacent to and downstream of the existing powerhouse, making use of the intake facilities and turbine bays to transmit flow to the new powerhouse through an opening in the rear wall of the former powerhouse.

6.1.2.3 Alternative C would require a temporary breach of the northerly abutment of the dam between the existing powerhouse and the spillway and the construction of a new powerhouse at the breached section.

6.1.2.4 Alternative D would locate the new powerhouse and intake facilities south of the southern abutment adjacent to the grounds of the library. In compliance with recommendations made by the Dam Inspection Report (Reference 1), careful consideration would be given to avoid reducing the flood-carrying capacity of the spillway. The City also plans to have a bike path along the southern bank of the river which would have to be incorporated into the site layout. The City presently utilizes a right-of-way along the southern bank for a sewer interceptor to which careful consideration would be given in siting the powerhouse and during construction. If the bike way or sewer interceptor provisions are maintained and the powerhouse structure is relocated so as to effect a reduction in the existing spillway discharge capacity, either supplemental spillway or gate of equal or improved flood carrying capacity would have to be designed into Alternative D.

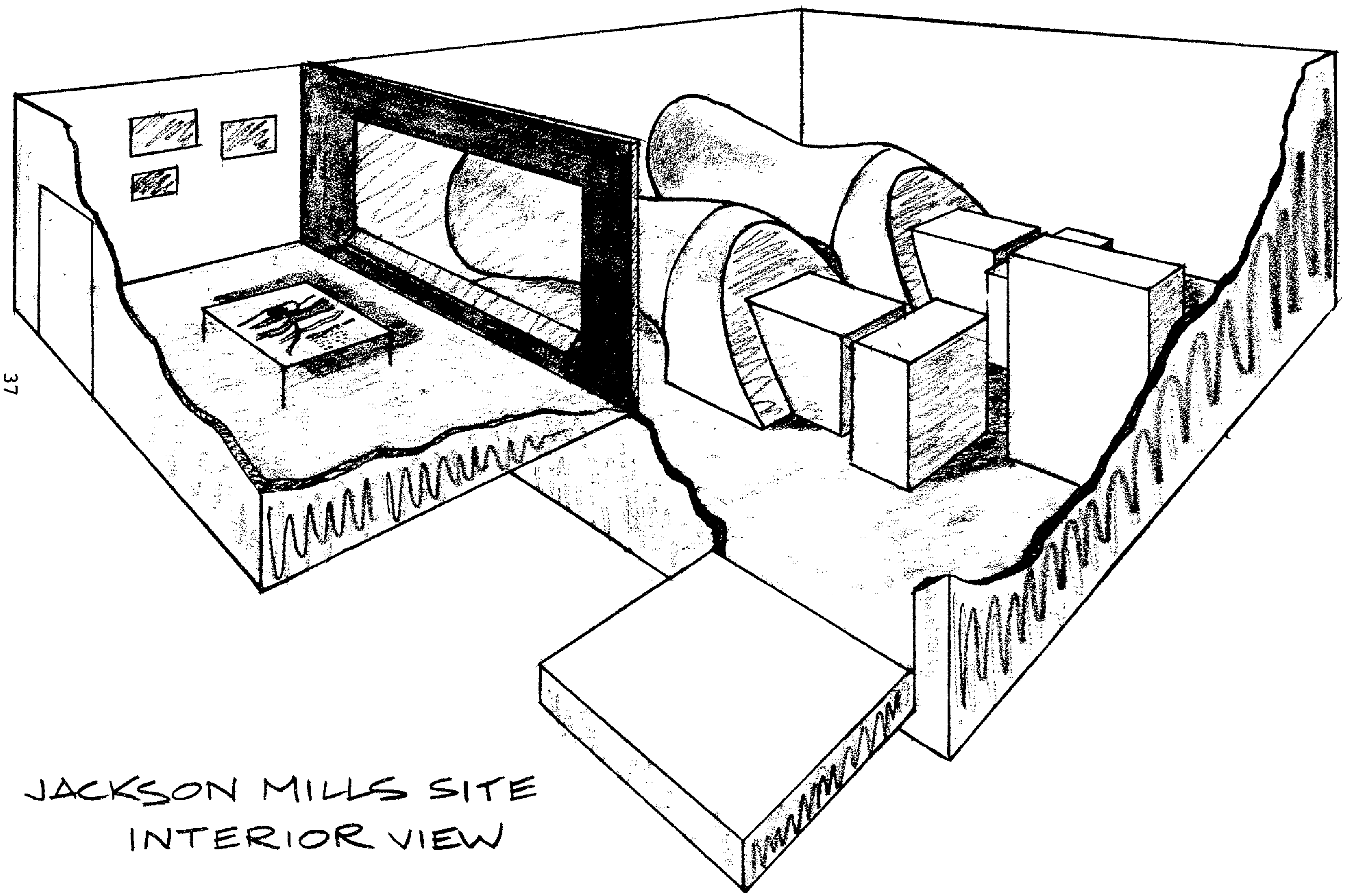
6.1.3 Table 2 summarizes the alternatives for decision evaluation. The table assumes that any powerhouse or architectural considerations will affect each alternative equally. The evaluation has been performed by listing significant decision factors and rating each factor by degree of negative impact on the alternative. As there are only four alternatives, it was felt that slight, moderate and considerable impacts, given a ranking of one to three respectively, could be totaled for each alternative. The alternative with the lowest total number would be evaluated and costed to determine if further investigation by a more detailed study is warranted. The decision factors are: Ownership - the impact of which was discussed in paragraph 6.1.1; Construction - the impacts of dewatering the site, potential breaching of the dam, and need for new intake facilities; Construction Access - the impact of the site on physical construction methods; Maintenance Access - the impact of regular equipment inspection, maintenance and cleaning of trash racks; and Educational Access - the impact of visitation by groups of school children and adults from Nashua and the surrounding area (See Plate 6, Appendix E).

6.1.4 The method of selection involved subjective consideration by the study team. The method resulted in the selection of Alternative D. The site would not have any of the ownership, construction, and maintenance problems which the other alternatives have. The site provides simple access for educational purposes and coordination with the library (See Figures 4 and 5). Although this alternative would require the temporary breaching of the dam, the addition of supplemental spillway length or a gate, and complex



JACKSON MILLS SITE

FIGURE 4



JACKSON MILLS SITE
INTERIOR VIEW

FIGURE 5

TABLE 2
ASSESSMENT OF ALTERNATIVES
BY IMPACT WEIGHTING

JACKSON MILLS DAM

DECISION IMPACTS*	ALTERNATIVES			
	A	B	C	D
Maintenance Access	3	2	2	1
Construction Access	1	2	3	1
Educational Access	3	2	3	2
Construction	1	2	3	3
Ownership	3	3	2	1
TOTAL	11	11	13	8

*Impact of architectural, aesthetic, and equipment considerations have been assumed to be equivalent for each alternative.

Degree of Impact
0 - None
1 - Slight
2 - Moderate
3 - Considerable

dewatering procedures, the costs and effects can be reasonably defined and many of the potentially expensive construction constraints for the other alternatives can not. For these reasons the preliminary evaluation of Alternative D seems justified.

6.2 Mine Falls Dam and Canal

6.2.1 Mine Falls Dam and canal form the southern boundary of Mine Falls Park, with the Nashua River forming the northern boundary. The effect of hydroelectric development on the park constitutes a major impact on alternative selection. The potential use of the canal system for swimming, boating, and skating demand that strict water-level control must be maintained. Flow velocities in the canal must be maintained at low rates to allow recreational use. The natural beauty of the park must be preserved; therefore, any buildings must be attractive, penstocks and transmission lines must be buried, and clearing of trees kept to a minimum. As mentioned in Section 4.0, there is historical interest in the gatehouse and archaeological value in the cliffs on the north side of the dam and potentially throughout the area north of the mill pond. The threat of vandalism exists throughout the park but could be reduced near the access points with sufficient lighting. As at Jackson Mills Dam, educational value can be derived from displays and observation points; therefore, easy access must be provided.

6.2.2 The Mine Falls alternative hydropower generating sites were selected with the assumption that a portion of or all of the Mine Falls Dam/gatehouse/canal system can be utilized. The possible alternatives are located on Plates 7, 8, and 9 (Appendix E).

6.2.2.1 Alternative A would require construction of an intake through the dam to transmit the water via penstock of large diameter along the base of the cliffs on the north side of the river to a powerhouse located at the base of the slope.

6.2.2.2 Alternative B would also require construction of an intake through the dam and the construction of a penstock following the level ground to reach the edge of the transmission line right-of-way in as short a distance as possible. The penstock would follow the right-of-way to the access road and then follow the road to the powerhouse at the base of the slope. Both alternatives would require the long penstocks to be buried where the depth to bedrock is shallow.

6.2.2.3 Alternative C would require an inlet through the dike on the mill pond. It would transmit the flow to a powerhouse at the head of a tailwater canal which roughly follows an old stream bed presently carrying overflow from the mill pond.

6.2.2.4 Alternative D would require a tailwater canal aligned as for Alternative C. The penstock and tailwater canal length would be reduced but the inlet would have to be in the old power canal. It is important to note that Alternatives D,E,F,G,H, and I will use the canal to carry the flow and that the canal flow should be limited to no more than 600 cubic feet per second. The canal would have to be desilted and cleaned at an expense directly related to the distance required.

6.2.2.5 Alternative E would be considered if the other alternatives prove aesthetically unacceptable as the penstock would utilize the area cut back for the transmission line right-of-way.

6.2.2.6 Alternative F requires a moderate length of canal and a very short length of penstock.

6.2.2.7 Alternative G is nearly identical to F but would require more canal and would have reduced accessibility.

6.2.2.8 Alternative H has been sited beyond the boundary of the park and utilizes a short penstock. It would require an opening of the oxbow for use as a tailrace. The land is owned by the Nashua Foundation and would have to be acquired.

6.2.2.9 Alternative I would require lining the overflow culvert for penstock stresses, acquiring the mill building and reconstruction of the powerhouse.

6.2.3 Table 3 summarizes the alternative evaluation using a similar technique as described in Section 6.1.3. The table assumes powerhouse and equipment costs are identical for each alternative. The distance downstream from the dam yields no significant increase in available head as the river has such a flat gradient. The impacts on the evaluation process are rated as none, slight, moderate, considerable, and severe and are valued at 0,1,2,3 and 4. The impacts were summed with the smallest total yielding the alternative to be further evaluated. The engineering constraints were varied enough to require several decision categories: Penstock - the impact of

TABLE 3
ASSESSMENT OF ALTERNATIVES
BY IMPACT WEIGHTING

MINE FALLS DAM

DECISION IMPACTS*	A	B	C	D	E	F	G	H	I
	ALTERNATIVES								
Penstock	4	4	2	1	3	1	1	1	4
New Canal Construction	0	0	4	3	0	0	0	2	0
Canal Revitalization	0	0	0	1	2	2	3	4	4
Water Level Control	1	1	3	3	3	3	3	3	3
Hydraulic Capacity Limits	0	0	1	2	3	3	3	3	3
Access (Construction/Educational)	4	3	2	2	1	1	2	1	1
Aesthetics	3	3	4	4	1	2	2	0	0
Historical/Archeological	4	3	3	3	1	1	1	1	2
Ownership	0	0	0	0	0	0	0	2	3
TOTAL	16	14	19	19	14	13	15	17	20

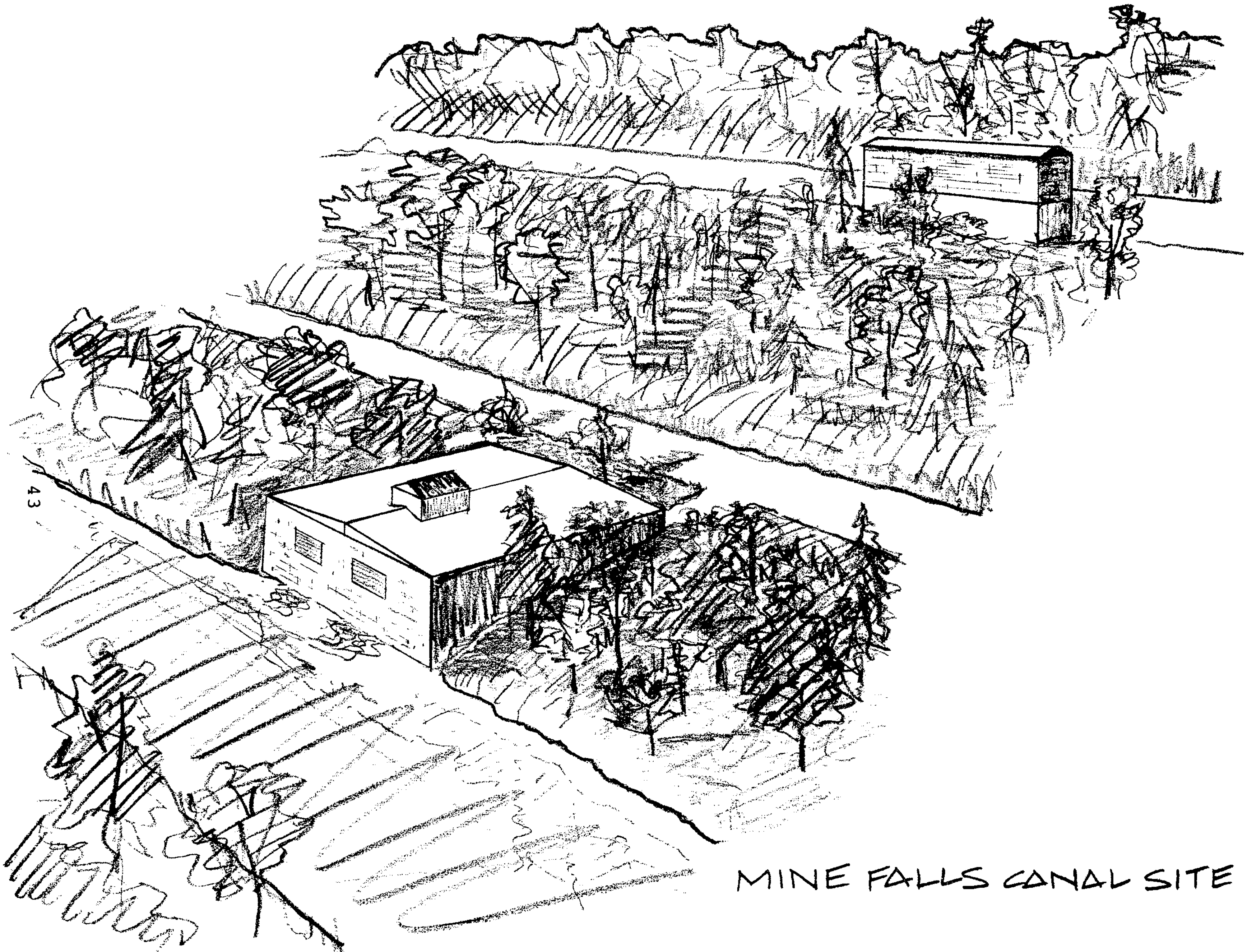
*Impact of powerhouse and equipment costs have been assumed to be equivalent for each alternative.

Degree of Impact
0 - None
1 - Slight
2 - Moderate
3 - Considerable
4 - Severe

total length and reported subsurface conditions; New Canal Construction - the total length and depth; Canal Revitalization - the total length and reinforcement of the old power canal; Water Level Control - the increased cost of maintaining water surface elevation; Hydraulic Capacity Limits - the impact of physical constraints on flow; and Access - the impact on construction, and vandalism. The other decision categories were: Aesthetic - the impact on the natural setting and the architectural requirements; Historical/Archaeological - the impact of known or potential historical or archaeological sites; Ownership - the impact of utilization of non-city property.

6.2.4 The method of selection incorporates individual subjective opinion but the alternative with the lowest total seems justified. Alternative F (See Plate 10, Appendix E and Figure 6) utilizes one of the shortest penstock lengths to be buried in soil which promises little bedrock. No tailrace canal would be built although a moderate length of the old canal would be revitalized. The site is easily accessed for construction and educational tour groups and has low potential for historical or archaeological value. The short penstock promises minimized aesthetic disruption, but the water level and hydraulic capacity are not as high as that of Alternatives A or B although the plant factor is reasonable. Alternative F seems to be a reasonable choice.

6.2.5 The necessity of strict water level maintenance in the millpond and canal would be consideration for Alternatives C through I. Water-level control at site F requires careful control of inflow to the pond and outflow through the turbines. This can be accomplished by renovating the existing gatehouse which will require the modification or replacement of the existing gates.



MINE FALLS CANAL SITE

FIGURE 6

7.0 SELECTED ALTERNATIVES

7.1 Powerhouse Characteristics

7.1.1 Powerhouse sites as selected in the previous section will be hereinafter called Mine Falls (Alternative F from Mine Falls, see Plate 10, Appendix E) and Jackson Mills (Alternative D from Jackson Mills, see Plate 6, Appendix E). The Mine Falls powerhouse would have two horizontal shaft propeller turbines in a tube arrangement with runner diameter of 1250 millimeters each capable of passing 300 cfs through an average head of 32 feet producing a total output of 1260 kilowatts for an average generation of 7,220,000 kilowatt hours.

7.1.2 The Jackson Mills powerhouse would contain two horizontal shaft propeller turbines with runners of 1500 millimeter diameter each capable of passing 400 cfs through an average head of 21 feet with an installed capacity of 1,050 kilowatts. The average annual energy generation would be 5,450,000 kilowatt hours. All three plants would be operated as an automatic run-of-river installation with daily maintenance limited to cleaning of trash racks and inspection of equipment to detect any problems. The objective would be to produce energy and not firm generation; therefore, only secondary energy would be produced at these sites.

7.2 Size, Capacities, and Materials

7.2.1 Foundations of the powerhouses would be mass poured concrete of appropriate strength; the powerhouse structures would be concrete walls with steel roofs. Brick or appropriate facade material would be used to maintain the aesthetic quality of the surroundings. The intake facilities will be poured concrete covered where possible to allow for indoor cleaning of trash racks and manual operation of gates. Trash racks will standard steel bar racks inclined for ease of cleaning. The penstock which will be used at Mine Falls will be 12-foot diameter pipe leading from the canal made of mill rolled steel welded together on the site. After passing through a wye, twin 9-foot diameter pipes of similar material and construction would carry water to the turbines. The transmission line would be of the 4.16 kv class, capable of being laid underwater or underground for transmission of power to substations of the Public Service Company of New Hampshire. No new ditches would be dug. A bypass, appropriately lined and with concrete retaining walls, would be dug around the right abutment of Jackson Mills Dam. The Mine Falls Canal would be desilted and restored to its original capacity. This would be required before any hydropower can be produced at that site. The block diagram for the induction generation is shown on Plate 11 in Appendix E.

7.3 Construction Schedule

7.3.1 The preliminary construction schedule appears on Figure 7. A period of six to eighteen months would precede the beginning of any construction or ordering of equipment once a decision to construct the project has been made. This period would be necessary to secure a license to operate the power stations (See Section 10.0). The construction period would begin in July since the late summer would be ideal for dewatering the site because of reduced summer flows. Once the construction began, work would be continuous except during the coldest winter months because of frozen soil conditions. The project should be on line 24 months after start of construction.

7.4 Construction Costs

7.4.1 The cost of the projects has been broken down and appears in Table 4. Potential fishway or environmental mitigation could not be quantified at this time. The costs have been estimated utilizing the limited data available on the sites. For this reason, costs may seem overly conservative for some items. These costs should be reviewed in detail in any further study.

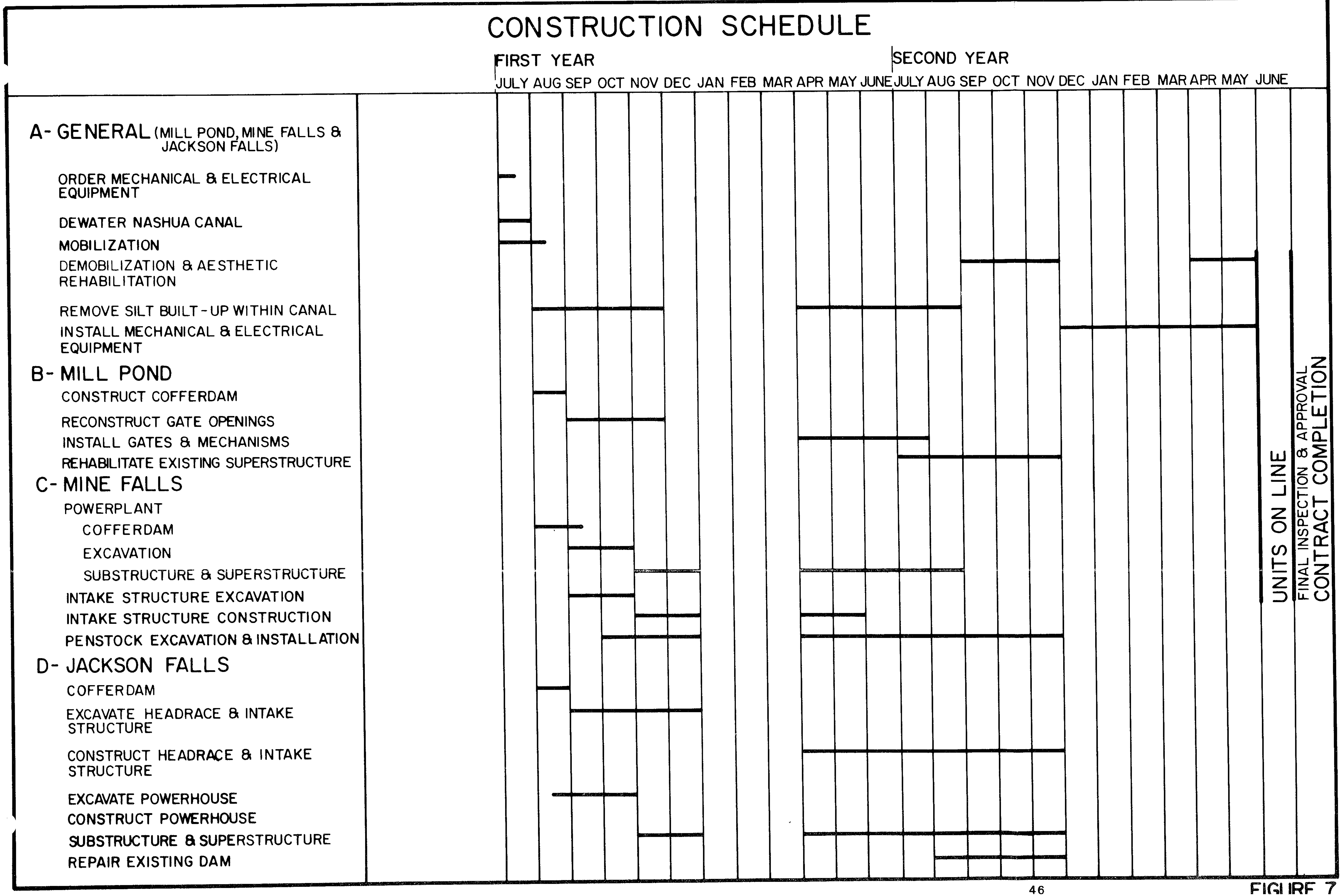

CONSTRUCTION SCHEDULE
FIRST YEAR
SECOND YEAR
JULY AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUNE
A- GENERAL (MILL POND, MINE FALLS & JACKSON FALLS)
ORDER MECHANICAL & ELECTRICAL EQUIPMENT
DEWATER NASHUA CANAL
MOBILIZATION
DEMOBILIZATION & AESTHETIC REHABILITATION
REMOVE SILT BUILT-UP WITHIN CANAL
INSTALL MECHANICAL & ELECTRICAL EQUIPMENT
B- MILL POND
CONSTRUCT COFFERDAM
RECONSTRUCT GATE OPENINGS
INSTALL GATES & MECHANISMS
REHABILITATE EXISTING SUPERSTRUCTURE
C- MINE FALLS
POWERPLANT
COFFERDAM
EXCAVATION
SUBSTRUCTURE & SUPERSTRUCTURE
INTAKE STRUCTURE EXCAVATION
INTAKE STRUCTURE CONSTRUCTION
PENSTOCK EXCAVATION & INSTALLATION
D- JACKSON FALLS
COFFERDAM
EXCAVATE HEADRACE & INTAKE STRUCTURE
CONSTRUCT HEADRACE & INTAKE STRUCTURE
EXCAVATE POWERHOUSE
CONSTRUCT POWERHOUSE
SUBSTRUCTURE & SUPERSTRUCTURE
REPAIR EXISTING DAM
UNITS ON LINE
FINAL INSPECTION & APPROVAL
CONTRACT COMPLETION

FIGURE 7

TABLE 4
CAPITAL COSTS
NASHUA RIVER HYDROPOWER PROJECTS

	MINE FALLS ($ in 1000's)	JACKSON MILLS ($ in 1000's)
Powerplant Structures and Improvements		
Diversion and care of water	40	15
Excavation and foundation preparation	110	140
Substructure	320	250
Superstructure/building	50	60
Miscellaneous allowance	50	50
Subtotal	570	515
Reservoir, Dam and Waterway		
Mine Falls Pond Gatehouse Renovation	400	
Trash Racks	42	42
Gates	50	50
Penstock	270	
Draft tube gates	18	18
Flashboards	26	10
Canal dredging and restoration	400	—
Subtotal	1206	120
Generating Plant and Equipment		
Turbine/generator/switchgear	800	700
Cabling	12	10
Installation	18	15
Miscellaneous powerhouse equipment	35	35
Substation equipment	15	15
Subtotal	880	775
TOTAL DIRECT COST	2656	1410
Engineering and Construction Supervision	531	290
Interest During Construction	100	100
Owner's Cost Allowance	50	30
Miscellaneous Costs	20	10
TOTAL CAPITAL COST	3357	1840

8.0 FINANCIAL ANALYSIS

8.1 Methodology and Assumptions

8.1.1 Table 5 presents a summary of the preliminary financial analysis of various interest rates. The analysis compares, using present worth, revenue (benefits) from the sale of power to cost of capital investment and operation and maintenance expenditures of the projects. Operation and maintenance for Jackson Mills has been assumed to be two percent annually of the Total Direct Cost shown in Table 4. For Mine Falls, the determination of operation and maintenance has been assumed to be two percent of the Total Direct Cost less the cost of the canal restoration ($400,000) as maintenance of the canal would be carried on as normal maintenance for Mine Falls Park and is not an additional cost to the hydroelectric project.

8.1.2 Hydropower generating equipment typically has a service life of 50 years, providing that it is well maintained. The equipment selected for this study has been designed for standard application, a concept which has only been on the market for a few years. Therefore, no experience data on equipment lifespan are available. As a result, a conservative lifespan of 40 years was assumed.

8.1.3 Because interest rates fluctuate, the analysis was computed using interest rates of 4 percent, 6 percent, 8 percent and 10 percent. At the time of this study, the City of Nashua would probably be able to obtain funds at about 6 percent. A private developer should expect to pay a higher rate.

8.1.4 The City of Nashua would presumably finance any hydropower development through the sale of 20-year bonds. In Appendix C, the annual cash flow for the amortization period and the balance of the project life have been estimated using average energy production and assuming that the project were financed with 6 percent 20-year bonds.

8.2 Conclusions

8.2.1 The results presented in Table 5 show that the economic outlook for developing the Jackson Mills site is excellent. The results at the Mine Falls site are not as optimistic. It should be noted that inflation has not been taken into consideration; therefore, the results are very conservative. It is our opinion that both sites should be investigated further in a more detailed study.

TABLE 5
PRESENT WORTH BENEFITS AND COSTS

JACKSON MILLS SITE
PROJECTED LIFE: 40 YEARS
INITIAL COST: $1,840,000
ENERGY: 5,450,000 kwh/yr.

	4%	6%	8%	10%
PRESENT WORTH BENEFITS	$4,315,000	$3,280,000	$2,600,000	$2,132,000
PRESENT WORTH COSTS	2,398,000	2,264,000	2,176,000	2,116,000
NET PRESENT VALUE	1,917,000	1,016,000	424,000	16,000
BENEFIT/COST RATIO	1.80	1.45	1.19	1.00

MINE FALLS SITE
PROJECTED LIFE: 40 YEARS
INITIAL COST: $3,357,000
ENERGY: 7,220,000 kwh/yr.

	4%	6%	8%	10%
PRESENT WORTH BENEFITS	$5,716,000	$4,345,000	$3,444,000	$2,824,000
PRESENT WORTH COSTS	4,250,000	4,036,000	3,895,000	3,798,000
NET PRESENT VALUE	1,466,000	309,000	451,000	974,000
BENEFIT/COST RATIO	1.34	1.08	0.88	0.74

9.0 EXISTING WATER RIGHTS AND RESTRICTIONS AND WATER DIVERSIONS

9.1 Water Rights and Restrictions

9.1.1 The City of Nashua acquired from the Nashua, New Hampshire Foundation the 325-acre tract of land that currently comprises Mine Falls Park, the Nashua Canal System, and the Mine Falls Dam and Gatehouse. The City was conveyed all flowage rights over lands upstream of Mine Falls Dam in Nashua and Hollis and the right to increase the elevation of the dam by 15 feet (Reference 10).

9.1.2 The City of Nashua appears to hold the flowage rights in the vicinity of Jackson Mills Dam. However, maintenance of a predetermined water surface elevation is required to provide enough head to maintain the flow of water for fire protection for Sanders Associates and the Nashua Corporation. Recommendation is made that further investigation into water rights be made by an attorney.

9.1.3 No documented legal flow restrictions relating either to the Mine Falls or Jackson Mills sites were encountered. The City is, however, required to maintain flow in the canal at a level satisfactory to the Nashua, New Hampshire Foundation or its successors. Specific flow restrictions placed by Federal and State agencies upon the hydropower developer will be determined during the licensing process. The effect of these restrictions on the analysis of these projects should be considered in a more detailed study.

9.1.4 The City of Nashua was granted a conservation easement by the Nashua, New Hampshire Foundation with a restriction to preserve and protect the Nashua River and riparian lands currently owned by the Foundation immediately upstream of Mine Falls Dam along the southern bank of the Nashua River (Reference 11).

9.2 Water Diversions

9.2.1 Associated with the Mine Falls Dam is a mill pond and canal owned by the City of Nashua. Water may be diverted from the Nashua River into the mill pond through an inlet gatehouse adjacent to the dam.

9.2.2 The mill pond and canal system were evaluated by Smith and Hamilton, Inc. in July of 1975. The analysis determined that the canal dike seems stable both by its 150-year record and technical computations, if it is maintained in good condition and not overtopped by floods. A number of recommendations should be heeded to restore it to good condition. They include: 1) clearing of trees from critical locations and the planting of shrubbery, 2) repairing the dike lining where scour has caused damage at water lines followed by re-seeding, 3) cleaning debris from canal, 4) filling existing animal burrows in the dike, 5) provide regular surveillance and a program to prevent or fill new burrows, and 6) provide for maintenance access (Reference 12).

9.2.3 Two emergency spillways (See Plate 7, Appendix E) have been built on the mill pond to accommodate increased flows. The flow into the canal system would be balanced by the capacities of the existing downstream overflow structure and the two emergency spillways.

10.0 REGULATORY AND LICENSING CONSIDERATIONS

10.1 Regulatory Considerations

10.1.1 The proposed projects are on the Nashua River which is currently classified as a navigable waterway. Thus, the project is under Federal Energy Regulatory Commission (F.E.R.C.) jurisdiction as well as State jurisdiction. Since the individual projects would have installed capacities of less than 2000 HP (1500 kw) a short-form license application for a minor project with F.E.R.C. can be employed. This license, a copy of which is presented in Appendix D, has incorproated a simplified procedure and format to save time and expense for the applicant.

10.1.2 The F.E.R.C. license application requires that permits and approvals be already obtained from numerous Federal, State, and local authorities. At the Federal level, a dredge and fill permit must be obtained from the U.S. Army Corps of Engineers, and approval of the proposed project is necessary from the U.S. Environmental Protection Agency and the Fish and Wildlife Service of the U.S. Department of the Interior. Required at the State level are approval of the dam's safety by the Water Resources Board, a dredge and fill permit from the Special Board of the Water Resources Board, a State water quality certificate and a dredge and fill permit from the Water Supply and Pollution Control Commission, and approvals from the Fish and Game Department and the Office of Historic Preservation of the Department of Resources and Economic Development. Prior to construction, determination will have to be made if local building permits will have to be acquired.

10.2 Licensing Considerations

10.2.1 Preliminary investigation suggests that the licensing procedure for the Mine Falls and Jackson Mills projects would cost more than $20,000. If the environmental report section in the license application was unacceptable to a State or Federal agency then an Environmental Impact Statement (E.I.S.) may be required. In this case, an additional $20,000-$100,000 expense and a minimum of a year project delay can be expected. Since both dams are existing and no major structural, hydraulic, or pollution modeling or analysis is anticipated, an E.I.S. for these projects would be a lesser expenditure. F.E.R.C. officials currently estimate the short-form licensing procedure, without the requirement of an E.I.S., will take from 3 to 6 months for review by their agency after all State and other Federal approvals have been obtained.

10.2.2 Final approval and licensing of Mine Falls and Jackson Mills projects will be based upon the assessment of the probable environmental impacts and the public needs including recreational, historical, and archaeological. Consideration will be made of the project's impact on land use, water quality, fish and wildlife, recreation, and historic and scenic value. Final approval will depend upon the applicant's ability to demonstrate that the proposed project will not endanger the safety, health, or welfare of the general public or abutting landowners and will maintain the existing natural environmental conditions.

10.2.3 Presented in Appendix D are two flow diagrams designed to show the procedure to follow for successfully obtaining State approval and Federal licensing for the proposed project. The darker arrows in the flow diagram indicate the expected/desired path to be followed in this proposed project to obtain the necessary approvals and F.E.R.C. licensing. A list of definitions of particular agencies, legislative statutes, and technical terms pertinent to hydropower development is also in the Appendix.

10.2.4 The filing of an application for a Preliminary Permit, although optional, is recommended for this project because first preference is given to municipalities over private developers. The purpose of this permit is to secure priority of application for license for a proposed project while the applicant obtains the data and necessary information to complete the license application. A permit, for a specified term, provides sole authority to develop a site and protects the investment in preparing feasibility studies and applying for a F.E.R.C. license. A contested license would further retard the licensing process (References 3 & 13).

APPENDIX A - Significant Correspondence and Memoranda

5th Congress

2d Session

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

COMMITTEE RESOLUTION

ESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, hat the Board of Engineers for Rivers and Harbors is hereby requested to review the eports of the Chief of Engineers on the Merrimack River, Massachusetts and New ampshire, published as House Document Number 689, 75th Congress, 3rd Session, and ther reports with a view to determining whether any modification of the recommenda- ions contained therein is advisable at the present time, with particular reference o, but not limited to, hydroelectric power development of the Jackson Mills and lines Falls Dam projects on the Nashua River, New Hampshire.

Jennings Randolph

nnings Randolph, CHAIRMAN

Robert T. Stafford, RANKING MINORITY MEMBER

Adopted: December 6, 1978

GPO 88-717-h

(At the request of Senator John A. Durkin, New Hampshire)

NEDPL-H 20 March 1979

Mr. George McGee, Chairman
New Hampshire Water Resources Board
37 Pleasant Street
Concord, New Hampshire 03301

Re: Jackson Mills and Mines Falls Dams
Nashua, New Hampshire - Project No. 14035

Dear Mr. McGee:

This is to advise you that this Division has been authorized to accomplish a feasibility study for generating electricity at Jackson Mills and Mines Falls Dams on the Nashua River in Nashua, New Hampshire.

Any information or material concerning the above project and which could be forwarded to this office would be appreciated.

Sincerely yours,

JOSEPH L. IGNAZIO
Chief, Planning Division

cc: Mr. Ron Poltak, Dir. of Ofc. State Plan., NH

STATE OF NEW HAMPSHIRE

Office of the Governor
2½ Beacon Street
Concord, NH 03301
603/271-2711
Toll Free 1-800-852-3466

Governor's Council on Energy

May 16, 1979

Mr. Joseph Ignazio
Chief, Planning Division
U.S. Army Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02154

Re: Jackson Mills and Mines Falls Dams, Nashua, New Hampshire - (W15#14035)

Dear Mr. Ignazio:

I direct your attention to the following pertinent material concerning hydro feasibility in New Hampshire.

- Legal Obstacles and Incentives to the Development of Small Scale Hydroelectric Power in New Hampshire, by the Energy Law Institute, Franklin Pierce Law Center, Concord, N.H. for the US DOE, contract #ET-78-S-02-4934, 1979.

- Fundamental Economic Issues in the Development of Small Scale Hydro, same author and contract.

- Report of the New Hampshire PUC on DE-78-232 and DE 78-233 concerning Rates for Sale of Power by Limited Electrical Energy Producers.

This last document is very important, as it establishes the rate for small (under 5MW) power producers under a state law of 1978. Until the regulations under PURPA Title II (the National Energy Act of 1978) are promulgated and the PUC reviews this rate, small hydro producers selling all of their power to the utility will receive 4.5¢ per kwhr for firm capacity and 4.0¢ per kwhr for non-firm capacity.

A piece of legislation is being considered this year in New Hampshire which would also give small power producers the right to have power wheeled by a utility to an ultimate customer. The legislation is receiving a favorab response, and could have substantial implications for the two sites in Nashua

I look forward to the Pre-Reconnaissance Report in June. If I can be of further assistance, please contact me.

Sincerely,

George R. Gantz
Director of Research
and
Policy Analysis

cc:
Mr. Alex Grier
Anderson-Nichols, Co.
150 Causeway St.
Boston, MA 02114

GRG/lb

LISTING OF CONTACT/COORDINATION DURING REPORT PREPARATION

AGENCY	INDIVIDUAL OR OFFICE CONTACTED	PURPOSE OF CONVERSATION/MEETING
Allis-Chalmers		Turbine units
Baker Library (Harvard University, Cambridge, Mass.)	Robert Lovett	Original engineering records of canal
Bofors-Nohab		Turbine units
City of Nashua	Mayor's office Tax Assessor Planning Board	Tax map data Mine Falls Park information & planning goals
Environmental Law Institute (Franklin Pierce Law Center, Concord, N.H.)	Peter Brown	Regulatory aspects of proposed projects
Hamilton Engineering (Nashua, N.H.)		Obtain engineering report on Mine Falls Park
James River-Pepperell Company (East Pepperell, Mass.)	Edmond Roux	Operating procedures of hydropower unit and flow maintenance upstream on Nashua River
Merrimack Valley Textile Museum (No. Andover, Mass.)	Angela Wright	Historical and engineering background on canal
Nissho-Iwai American Corp.		Turbine units
Nissitissit River Trust	Jeffrey Smith	Nissitissit River hydrology
Public Service Company of New Hampshire	John Lyons	Interstate grid determination
Society of Industrial Archeology (Elliot, Me.)	Richard Candee	Canal history and data

State of Massachusetts Water Pollution Control	Han Bonne	Flow Maintenance at James River-Pepperel] Company
State of New Hampshire		
Dept. of Fish and Game	Stephen Virgin	Regulatory aspect
Dept. of Resources and Economic Development	Gary Hume Joseph Quinn Linda Wilson	Archeological pot regulatory aspect historical signif cance relating to proposed projects
Governor's Council on Energy	George Gantz William Humm	Regulatory aspect and marketing
Public Utilities Commission	Bruce Ellsworth	Rate information
Water Pollution Control Commission	Walter Carlson Donald Chese-borough	Nashua River wate quality & state permits
Water Resources Board	Gary Kerr Vernon Knowlton	Dam safety and st permits from WRB
Sulzer Brothers, Inc.		Turbine units
Tampella-Madden Corp.		Turbine units
United States		
Federal Energy Regulatory Commission	Edward Abrams Ronald Corso	Regulatory aspect and licensing requirements
Geological Survey	William McDonough William Wandle	Nashua River hydrology

APPENDIX B - Hydrology and Turbine Sizing

Determination of Flow-Duration Curve for Nissitissit River

Note: Nissitissit River empties into Nashua River 0.8 miles downstream of East Pepperell, Mass. gage (USGS). Thus, additional flow contributed by the Nissitissit should be calculated and added to Nashua River flow values (at the gage) to compile a composite flow-duration curve for Nashua River to be employed at project sites downstream

Use regression equations developed for unregulated streams in New Hampshire from

Dingman, S. Lawrence, "Synthesis of Flow-Duration Curves for Unregulated Streams in New Hampshire". Water Resources Bulletin, December 1978, p. 1481.

PARAMETERS

DRAINAGE AREA = A_D = 58.2 MILES^2 (planimetered)

MAXIMUM BASIN ELEVATION = Y_{MAX} = 1040 NGVD (from USGS map)

MINIMUM BASIN ELEVATION = Y_{MIN} = 170 NGVD (from USGS map)

AVERAGE BASIN ELEVATION = $\hat{Y}$ (from regression equation)

$$\hat{Y} = Y_{MIN} + 0.324(Y_{MAX} - Y_{MIN}) = 170 + 0.324(1040-170) = 452 \text{ NGVD}$$

RELATIONSHIP BETWEEN MEAN FLOW ($\hat{Q}$) AND $\hat{Y}$ (from Dingman)

$$\hat{Q}_{(in/yr)} = 17.7 + 0.00697\hat{Y} = 20.9 \text{ IN/YR OVER WATERSHED}$$

$$\hat{Q} = 20.9 \text{ IN/YR OVER BASIN} = \frac{20.9 \text{ IN/YR} \times 1 \text{ FT}/12 \text{ IN} \times 58.2 \text{ MI}^2 \times (5280 \text{ FT/MI})^2}{365 \text{ DAYS/YR} \times 24 \text{ HR/DAY} \times 3600 \text{ SEC/HR}} = 89.6 \text{ c}$$

OR $\hat{Q} = (1.30 + 0.00513\hat{Y})A_D = 90$ CFS (REGION I IN N.H.)

$\hat{Q}$ = 90 CFS WHICH GENERALLY THE FLOW EQUALLED OR EXCEEDED 21% F THE TIME (Dingman)

DETERMINATION OF OTHER FLOW VALUES IS:

Q_{95} = FLOW EQUALLED OR EXCEEDED 95% OF THE

$$= \left[0.0796 - (0.107)(10^{-3})(\hat{Y}) + (0.901)(10^{-7})(\hat{Y})\right] A_i$$

$$= 2.9 \text{ CFS}$$

$Q_{30} = 0.880\,\hat{Q} = 79$ CFS

$Q_{5} = 3.90\,\hat{Q} = 351$ CFS

$Q_{2} = 6.00\,\hat{Q} = 540$ CFS

IN TABULAR FORM, FLOW VARIABILITY FOR NISSITISSIT RIVER IS

PERCENT OF TIME FLOW VALUE IS EQUALLED OR EXCEEDED	DISCHARGE (CFS)
2	540
5	351
27	90
30	79
95	3

THESE ARE TO BE ADDED TO NASHUA RIVER FLOW-DURATION DATA DEVELOPED FOR USGS GAGE FOR COMPOSITE FLOW-DURATION CURVE FIGURE 3 IN TEXT

STATION NUMBER 01096500

DURATION TABLE OF DAILY VALUES FOR YEAR ENDING SEPTEMBER 30

DISCHARGE, IN CUBIC FEET PER SECOND
MEAN
NASHUA RIVER AT EAST PEPPERELL, MA

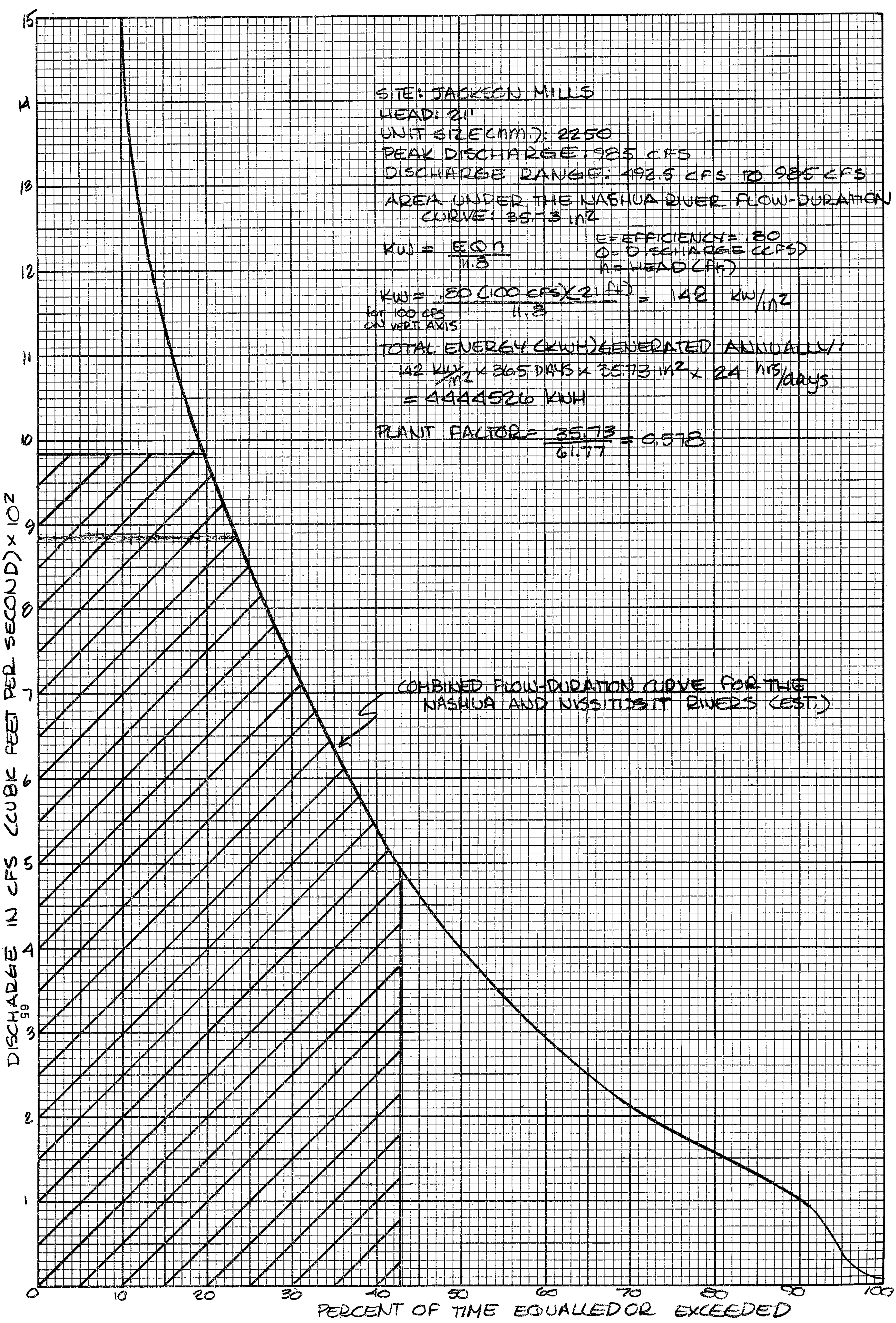
NUMBER OF DAYS IN CLASS

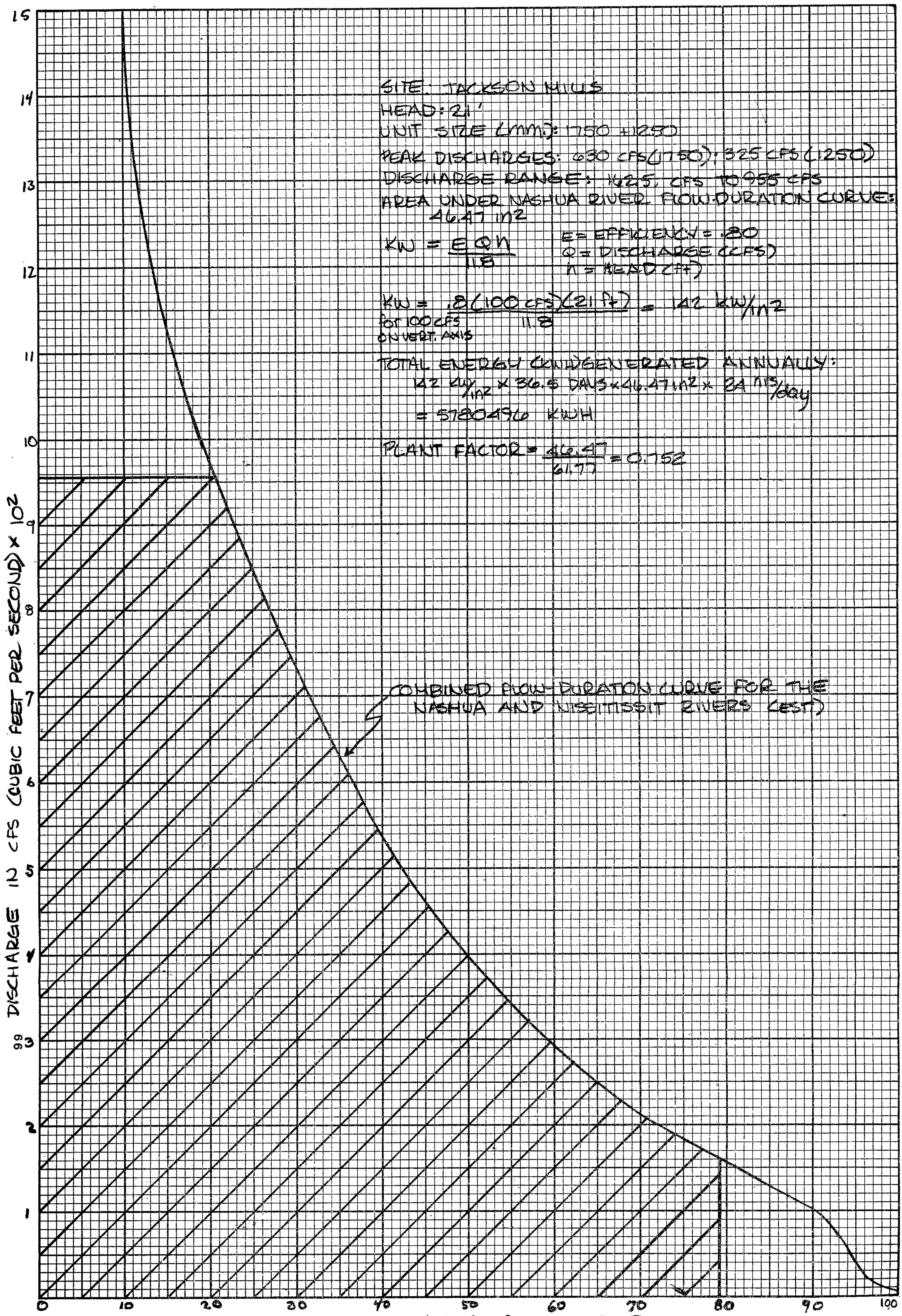
CLASS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
YEAR 1976					4	2	12	7	5		1		1	10	5	3	8	21	27	23	21	29	56	47	38	22	14	8	2				

CLASS	VALUE	TOTAL	ACCUM	PERCT	CLASS	VALUE	TOTAL	ACCUM	PERCT	CLASS	VALUE	TOTAL	ACCUM	PERC
0	0.00	0	14976	100.0	12	38.0	95	14188	94.7	24	970	1292	2596	17.
1	2.00	1	14976	100.0	13	50.0	246	14093	94.1	25	1300	530	1304	8.
2	2.60	2	14975	100.0	14	66.0	277	13847	92.5	26	1700	393	774	5.
3	3.40	11	14973	100.0	15	86.0	628	13570	90.6	27	2200	212	381	2.
4	4.50	36	14962	99.9	16	110.0	977	12942	86.4	28	2800	111	169	1.
5	5.90	95	14926	99.7	17	150.0	1346	11965	79.9	29	3700	35	58	.
6	7.70	180	14831	99.0	18	190.0	1385	10619	70.9	30	4800	12	23	.
7	10.00	154	14651	97.8	19	250.0	1371	9234	61.7	31	6300	6	11	
8	13.00	154	14497	96.8	20	330.0	1406	7863	52.5	32	8300	2	5	
9	17.00	66	14343	95.8	21	430.0	1183	6457	43.1	33	11000	1	3	
10	22.00	47	14277	95.3	22	560.0	1464	5274	35.2	34	14000	2	2	
11	29.00	42	14230	95.0	23	740.0	1214	3810	25.4					

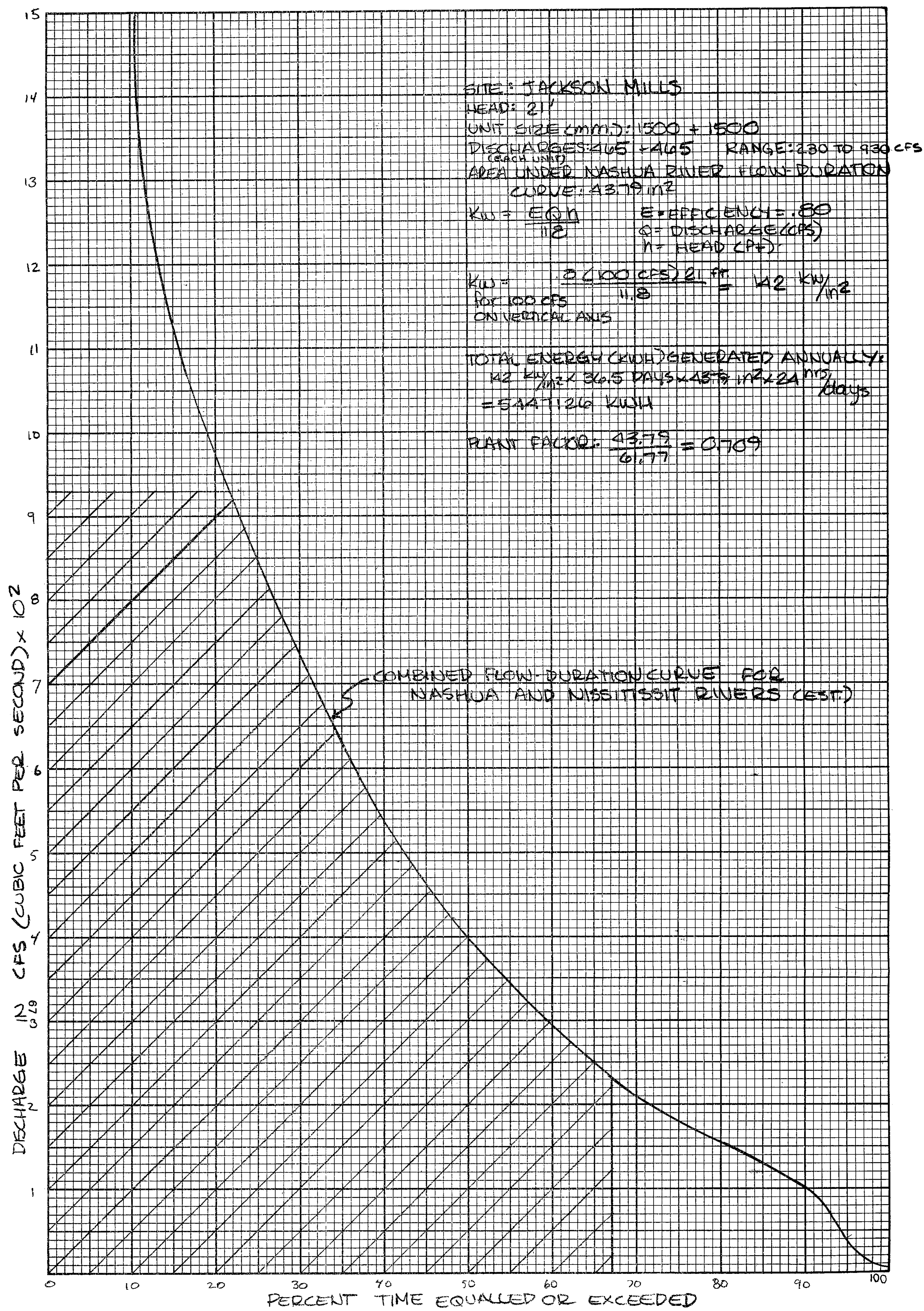
VALUE EXCEEDED 'P' PERCENT OF TIME

V95 = 30.00
V90 = 90.00
V75 = 170.00
V70 = 200.00
V50 = 360.00
V25 = 750.00
V10 = 1300.00

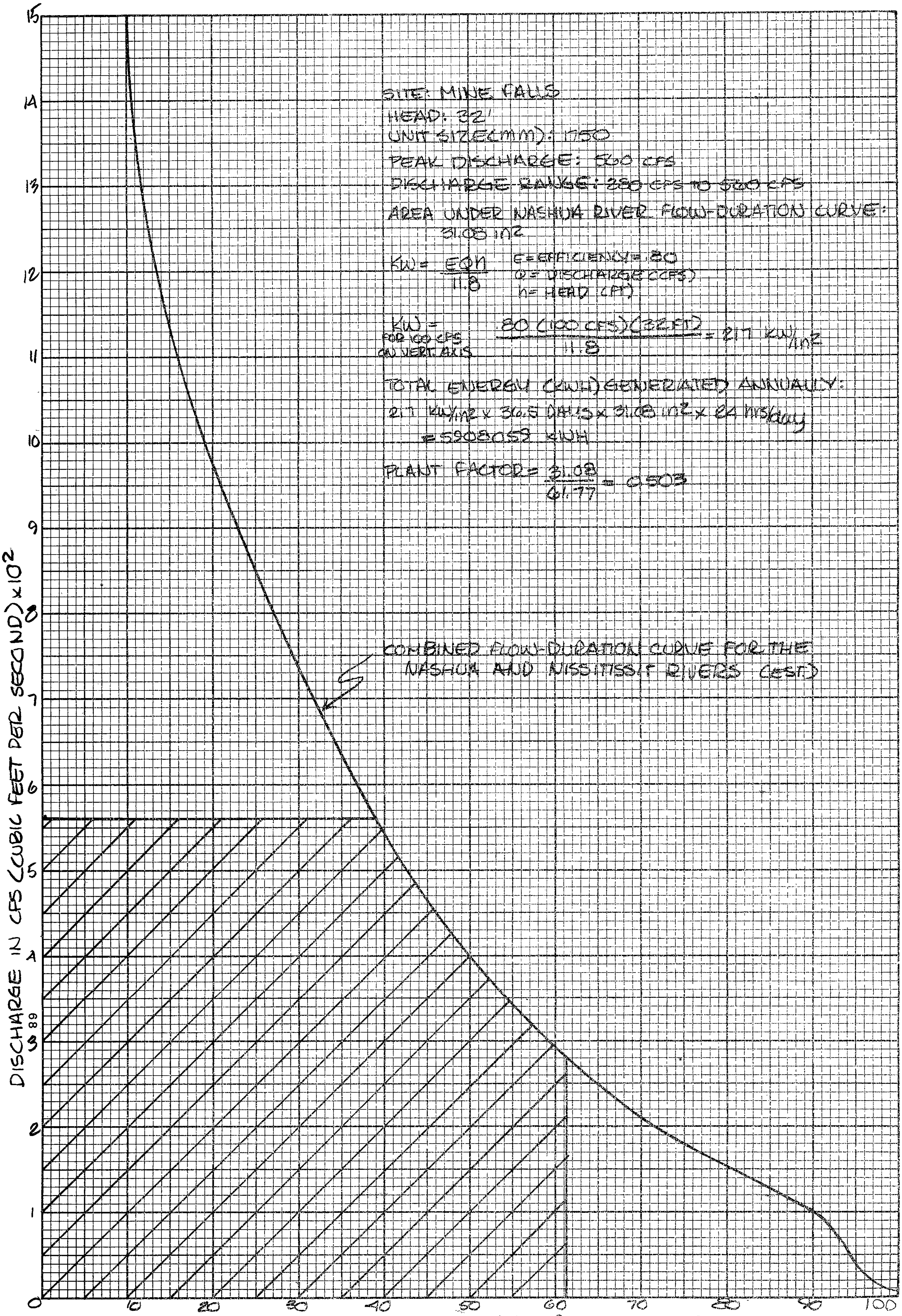

SITE: JACKSON MILLS
HEAD: 21'
UNIT SIZE (MM.): 2250
PEAK DISCHARGE: 985 CFS
DISCHARGE RANGE: 492.5 CFS TO 985 CFS
AREA UNDER THE NASHUA RIVER FLOW-DURATION CURVE: 35.73 in2
KW = EQh / 11.8
E = EFFICIENCY = .80
Q = DISCHARGE (CFS)
h = HEAD (ft)
KW = .80 (100 CFS)(21 ft) / 11.8 = 142 KW/in2
for 100 CFS on VERT AXIS
TOTAL ENERGY (KWH) GENERATED ANNUALLY:
142 KW/in2 × 365 DAYS × 35.73 in2 × 24 hrs/days
= 4444526 KWH
PLANT FACTOR = 35.73 / 61.77 = 0.578
COMBINED FLOW-DURATION CURVE FOR THE NASHUA AND NISSITISSIT RIVERS (EST.)
DISCHARGE IN CFS (CUBIC FEET PER SECOND) × 10²
PERCENT OF TIME EQUALLED OR EXCEEDED
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

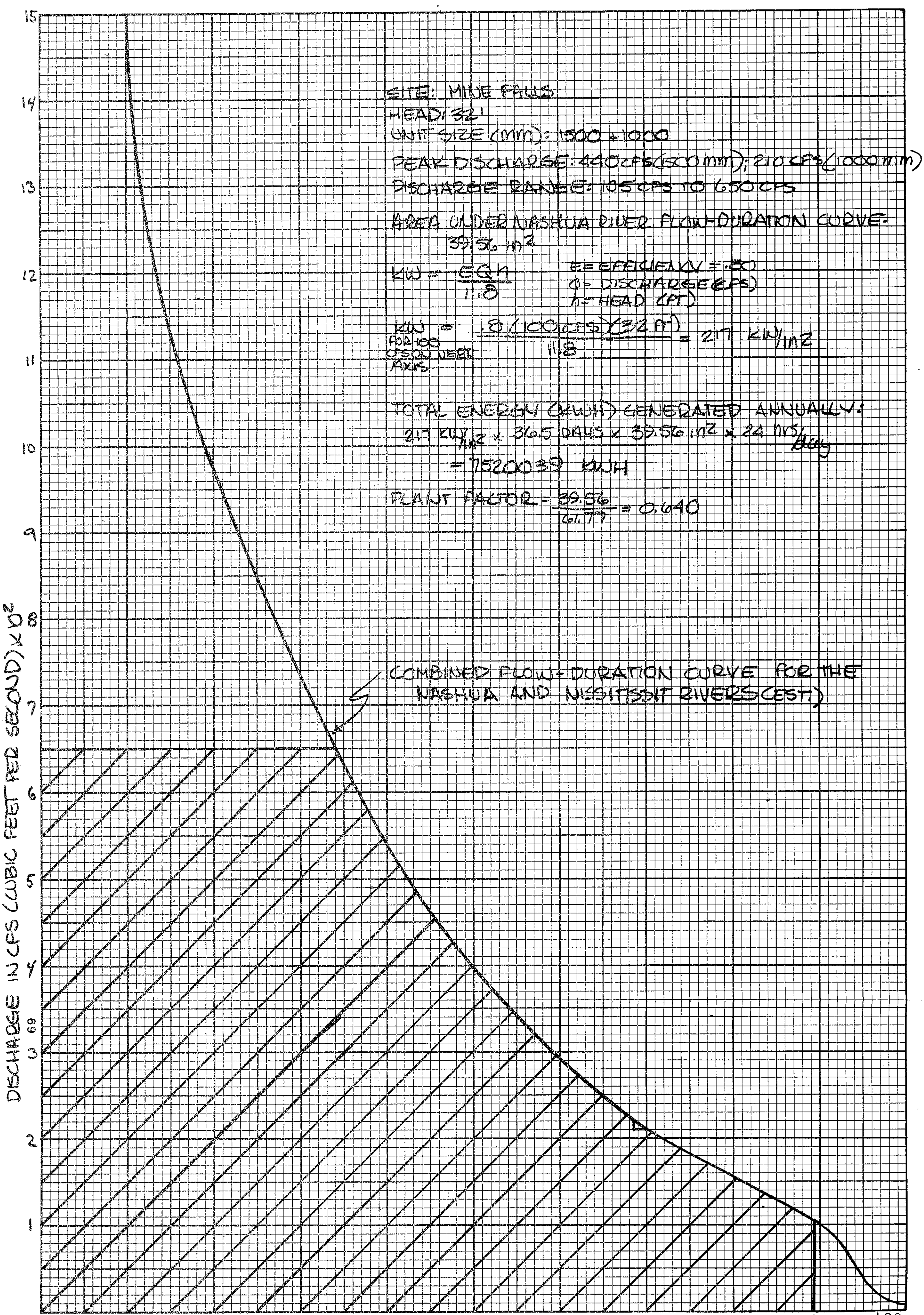


SITE: JACKSON MILLS
HEAD: 21'
UNIT SIZE (mm): 1750 + 1250
PEAK DISCHARGES: 630 CFS (1750); 325 CFS (1250)
DISCHARGE RANGE: 1625 CFS TO 955 CFS
AREA UNDER NASHUA RIVER FLOW-DURATION CURVE: 46.47 in2
KW = EQh / 11.8
E = EFFICIENCY = .80
Q = DISCHARGE (CFS)
h = HEAD (ft)
KW = .8(100 CFS)(21 ft) / 11.8 = 142 KW/in2
for 100 CFS ON VERT. AXIS
TOTAL ENERGY (KWH) GENERATED ANNUALLY:
142 KW/in2 × 365 DAYS × 46.47 in2 × 24 hrs/day
= 57804960 KWH
PLANT FACTOR = 46.47 / 61.77 = 0.752
COMBINED FLOW-DURATION CURVE FOR THE NASHUA AND NISSITISSIT RIVERS (EST)
DISCHARGE IN CFS (CUBIC FEET PER SECOND) × 10²
PERCENT OF TIME EQUALLED OR EXCEEDED

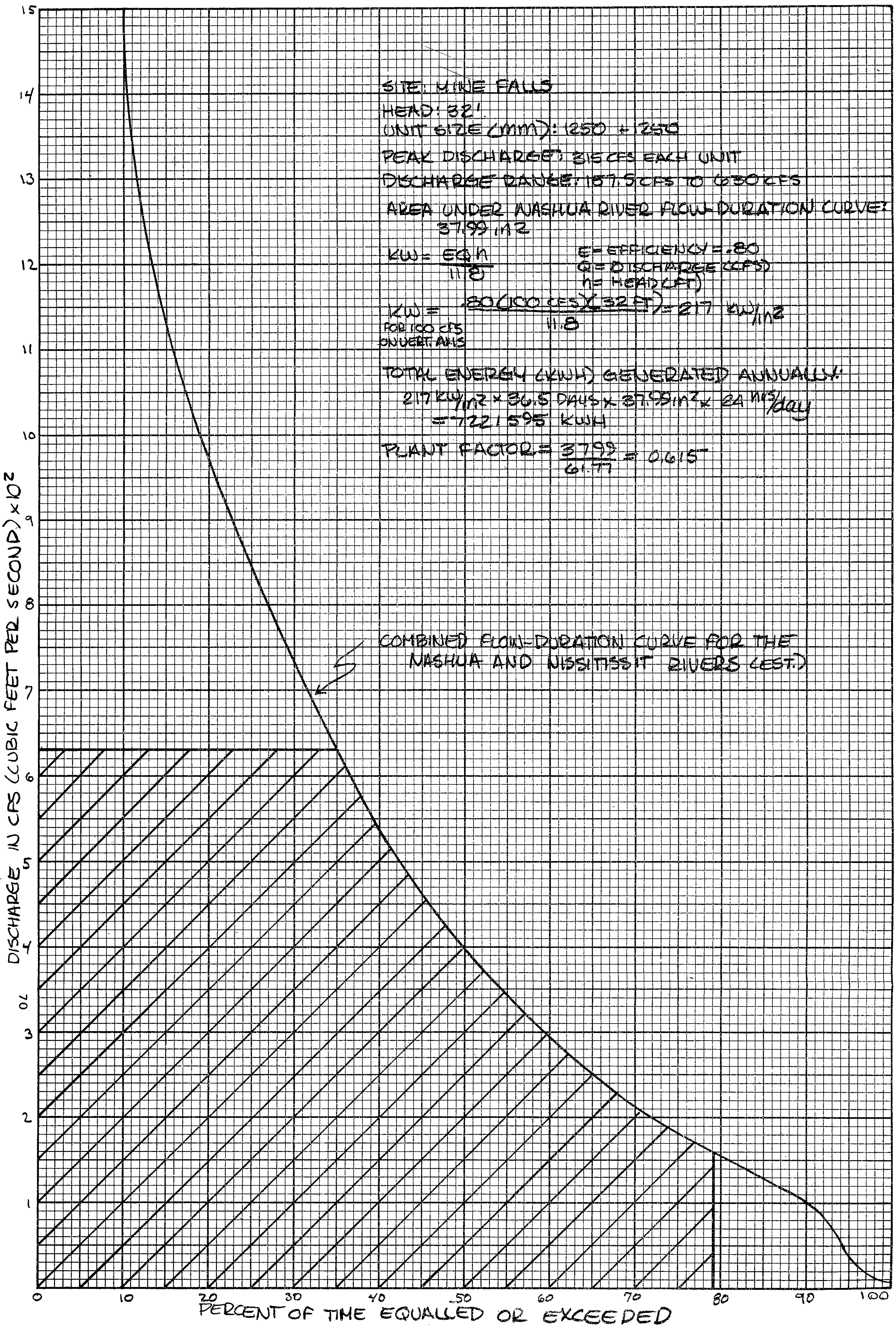


SITE: JACKSON MILLS
HEAD: 21'
UNIT SIZE (mm.): 1500 + 1500
DISCHARGES: 465 + 465 (EACH UNIT) RANGE: 230 TO 930 CFS
AREA UNDER NASHUA RIVER FLOW-DURATION CURVE: 43.79 in²
KW = EQh / 11.8
E = EFFICIENCY = .80
Q = DISCHARGE (CFS)
h = HEAD (ft)
KW = .8 (100 CFS) 21 ft / 11.8 = 142 KW/in²
for 100 CFS ON VERTICAL AXIS
TOTAL ENERGY (KWH) GENERATED ANNUALLY:
142 KW/in² × 365 DAYS × 43.79 in² × 24 hrs/days
= 5447126 KWH
PLANT FACTOR: 43.79 / 61.77 = 0.709
COMBINED FLOW-DURATION CURVE FOR NASHUA AND NISSITISSIT RIVERS (EST.)
DISCHARGE IN CFS (CUBIC FEET PER SECOND) × 10²
PERCENT TIME EQUALLED OR EXCEEDED
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15


SITE: MINE FALLS
HEAD: 32'
UNIT SIZE(mm): 1750
PEAK DISCHARGE: 560 CFS
~~DISCHARGE RANGE: 280 CFS TO 560 CFS~~
AREA UNDER NASHUA RIVER FLOW-DURATION CURVE:
31.08 in2
KW = EQh / 11.8
E = EFFICIENCY = .80
Q = DISCHARGE (CFS)
h = HEAD (FT)
KW = FOR 100 CFS ON VERT. AXIS
.80 (100 CFS)(32 FT) / 11.8 = 217 KW/in2
TOTAL ENERGY (KWH) GENERATED ANNUALLY:
217 KW/in2 x 365 DAYS x 31.08 in2 x 24 hrs/day
= 59080559 KWH
PLANT FACTOR = 31.08 / 61.77 = 0.503
COMBINED FLOW-DURATION CURVE FOR THE NASHUA AND NISSITISSIT RIVERS (EST.)
DISCHARGE IN CFS (CUBIC FEET PER SECOND) x10²
PERCENT OF TIME EQUALLED OR EXCEEDED
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
10
20
30
40
50
60
70
80
90
100



SITE: MINE FALLS
HEAD: 32'
UNIT SIZE (mm): 1500 + 1000
PEAK DISCHARGE: 440 CFS (1500 mm); 210 CFS (1000 mm)
DISCHARGE RANGE: 105 CFS TO 650 CFS
AREA UNDER NASHUA RIVER FLOW-DURATION CURVE: 39.56 in²
KW = EQh / 11.8
E = EFFICIENCY = .80
Q = DISCHARGE (CFS)
h = HEAD (FT)
KW FOR 100 CFS ON VERT AXIS = .8 (100 CFS)(32 FT) / 11.8 = 217 KW/in²
TOTAL ENERGY (KWH) GENERATED ANNUALLY:
217 KW/in² x 365 DAYS x 39.56 in² x 24 hrs/day
= 7520039 KWH
PLANT FACTOR = 39.56 / 61.77 = 0.640
COMBINED FLOW-DURATION CURVE FOR THE NASHUA AND NISSITISSIT RIVERS (EST.)
DISCHARGE IN CFS (CUBIC FEET PER SECOND) x 10²
PERCENT OF TIME EQUALLED OR EXCEEDED
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15



SITE: MINE FALLS
HEAD: 32'
UNIT SIZE (mm): 1250 + 1250
PEAK DISCHARGE: 315 CFS EACH UNIT
DISCHARGE RANGE: 157.5 CFS TO 630 CFS
AREA UNDER NASHUA RIVER FLOW-DURATION CURVE: 37.99 in2
KW = EQh / 11.8
E = EFFICIENCY = .80
Q = DISCHARGE (CFS)
h = HEAD (FT)
KW = .80 (100 CFS)(32 FT) / 11.8 = 217 KW/in2
FOR 100 CFS ON VERT. AXIS
TOTAL ENERGY (KWH) GENERATED ANNUALLY:
217 KW/in2 × 36.5 DAYS × 37.99 in2 × 24 hrs/day
= 7221595 KWH
PLANT FACTOR = 37.99 / 61.77 = 0.615
COMBINED FLOW-DURATION CURVE FOR THE NASHUA AND NISSITISSIT RIVERS (EST.)
DISCHARGE IN CFS (CUBIC FEET PER SECOND) × 10^2
PERCENT OF TIME EQUALLED OR EXCEEDED
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0
10
20
30
40
50
60
70
80
90
100

APPENDIX C - Financial Analysis Computations

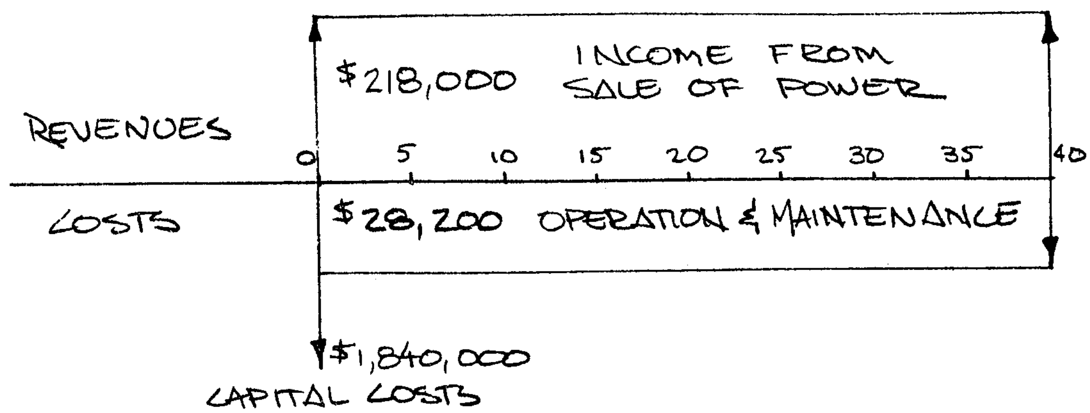
BENEFIT/COST ANALYSIS

JACKSON MILLS

COMPUTED: KH
CHECKED: SDM

PROJECT LIFE: 40 YEARS
INITIAL COST: $1,840,000
ENERGY: 5,450,000 KWH/YR.
BENEFITS: 4¢/KWH

INTEREST RATE: 4%



OPERATION & MAINTENANCE = 2% (TOTAL DIRECT COST)
= .02 ($1,410,000) = $28,200
(SEE SECT. 8.1.1)

REVENUES = (5,450,000 KWH/YR.) (4¢/KWH)
= $ 218,000/YR.

PRESENT WORTH BENEFITS = $218,000 $(P/a)^{4\%}_{40}$
= $218,000 (19.793)
= $ 4,314,874

PRESENT WORTH COSTS = $1,840,000 + $28,200 $(P/a)^{4\%}_{40}$
= $1,840,000 + $558,163
= $2,398,163

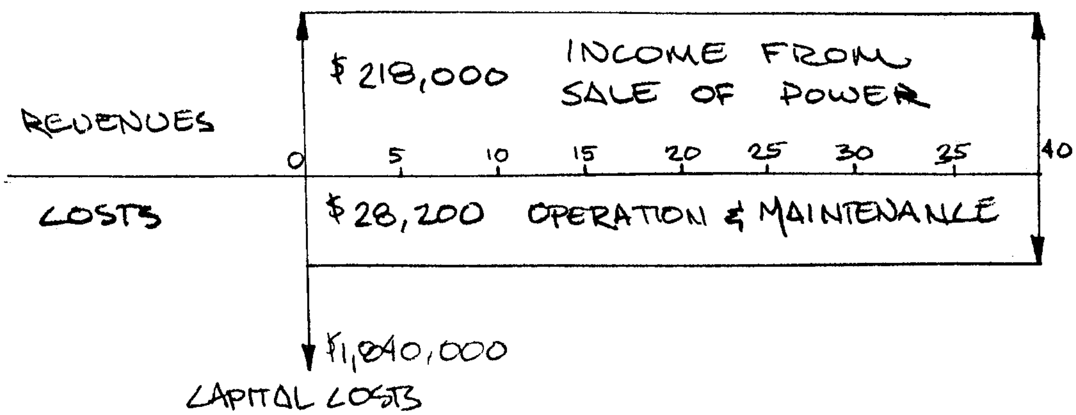
BENEFITS/COSTS = $\dfrac{\$4,314,874}{\$2,398,163}$ = 1.80

BENEFIT/COST ANALYSIS

COMPUTED KH
CHECKED SDT

JACKSON MILLS
PROJECT LIFE: 40 YEARS
INITIAL COST: $1,840,000
ENERGY: 5,450,000 KWH/YR.
BENEFITS: 4¢/KWH

INTEREST RATE: 6%



OPERATION & MAINTENANCE = 2% (TOTAL DIRECT COST)
= .02 ($1,410,000) = $28,200
(SEE SECT. 8.1.1)

REVENUES = (5,450,000 KWH/YR.) (4¢/KWH)
= $218,000/YR.

$$\text{PRESENT WORTH BENEFITS} = \$218{,}000\ (P/a)^{6\%}_{40}$$
$$= \$218{,}000\ (15.046)$$
$$= \$3{,}280{,}028$$

$$\text{PRESENT WORTH COSTS} = \$1{,}840{,}000 + \$28{,}200\ (P/a)$$
$$= \$1{,}840{,}000 + \$424{,}297$$
$$= \$2{,}264{,}297$$

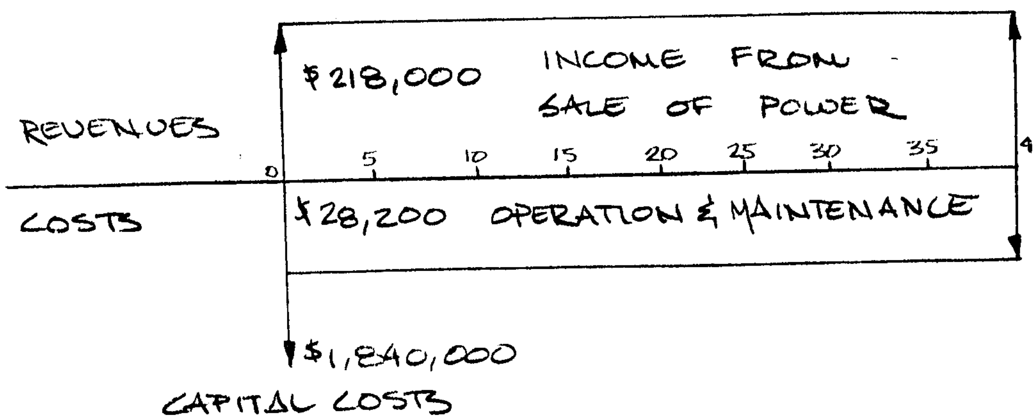
$$\text{BENEFITS/COSTS} = \frac{\$3{,}280{,}028}{\$2{,}264{,}297} = \underline{1.45}$$

BENEFIT/COST ANALYSIS

COMPUTED KH
CHECKED SDM

JACKSON MILLS
PROJECT LIFE: 40 YEARS
INITIAL COST: \$1,840,000
ENERGY: 5,450,000 KWH/YR.
BENEFITS: 4¢/KWH

INTEREST RATE: <u>8%</u>



OPERATION & MAINTENANCE = 2% (TOTAL DIRECT COST)
= .02 (\$1,410,000) = \$28,200
(SEE SECT 8.1.1)

REVENUES = (5,450,000 KWH/YR)(4¢/KWH)
= \$218,000/YR.

PRESENT WORTH BENEFITS $= \$218{,}000\ (P/a)^{8\%}_{40}$
= \$218,000 (11.925)
= \$2,599,650

PRESENT WORTH COSTS $= \$1{,}840{,}000 + \$28{,}200\ (P/a)^{8\%}_{40}$
= \$1,840,000 + \$336,285
= \$2,176,285

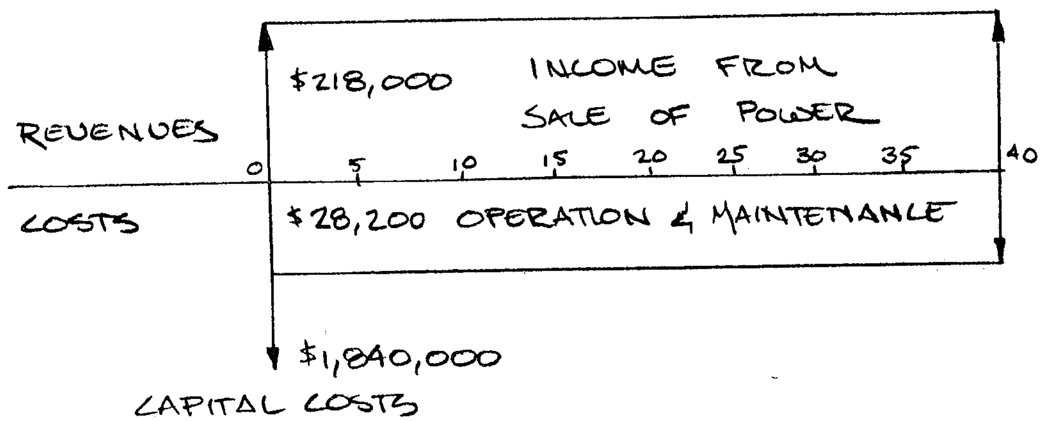
BENEFITS/COSTS $= \dfrac{\$2{,}599{,}650}{\$2{,}176{,}285} = \underline{1.19}$

BENEFIT/COST ANALYSIS

COMPUTED
CHECKED

JACKSON MILLS
PROJECT LIFE: 40 YEARS
INITIAL COST: $1,840,000
ENERGY: 5,450,000 KWH/YR.
BENEFITS: 4¢/KWH

INTEREST RATE: 10%



OPERATION & MAINTENANCE = 2% (TOTAL DIRECT COS
= .02 ($1,410,000) = $28,200
(SEE SECT 8

REVENUES = (5,450,000 KWH/YR.) (4¢/KWH)
= $ 218,000/YR.

PRESENT WORTH BENEFITS = $218,000 $(P/a)^{10\%}_{40}$
= $218,000 (9.779)
= $2,131,822

PRESENT WORTH COSTS = $1,840,000 + $28,200 (P/a
= $1,840,000 + $275,768
= $2,115,768

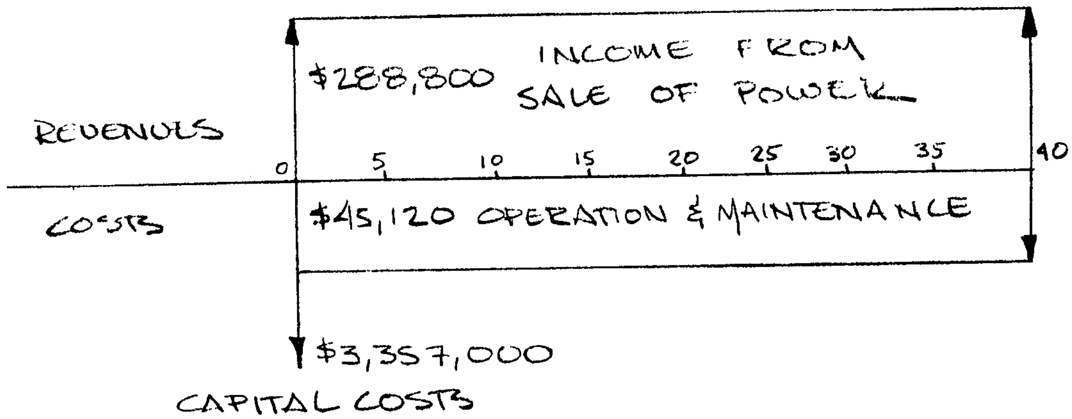
BENEFITS/COSTS = $\dfrac{\$2,131,822}{\$2,115,768}$ = 1.00

BENEFIT / COST ANALYSIS

COMPUTED KH
CHECKED SOM

MINE FALLS
PROJECT LIFE: 40 YEARS
INITIAL COST: $3,357,000
ENERGY: 7,220,000 KWH/YR.
BENEFITS: 4¢/KWH

INTEREST RATE: 4%



OPERATION & MAINTENANCE = 2% (TOTAL DIRECT COST
— COST OF CANAL RESTORATION
⇒ RESPONSIBILITY OF MAINTENANCE TO
NASHUA RECREATION & PARKS (SEE SECT. 8.1.1))
= .02 ($2,656,000 - $400,000)
= $45,120

REVENUES = (7,220,000 KWH/YR)(4¢/KWH)
= $288,800/YR.

PRESENT WORTH BENEFITS = $288,800 $(P/a)^{4\%}_{40}$
= $288,800 (19.793)
= $5,716,218

PRESENT WORTH COSTS = $3,357,000 + $45,120 $(P/a)^{4\%}_{40}$
= $3,357,000 + $893,060
= $4,250,060

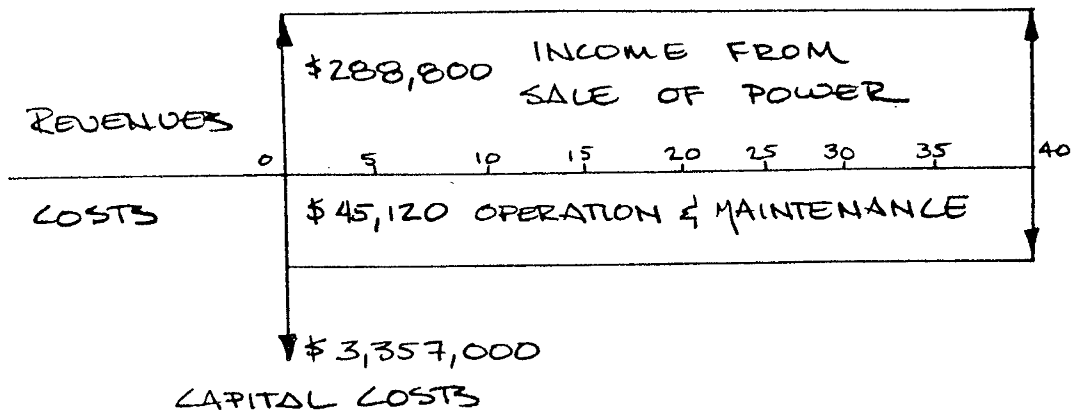
BENEFITS/COSTS = $\dfrac{\$5,716,218}{\$4,250,060}$ = 1.34

BENEFIT/COST ANALYSIS

COMPUTED K
CHECKED S

MINE FALLS
PROJECT LIFE: 40 YEARS
INITIAL COST: $3,357,000
ENERGY: 7,220,000 KWH/YR.
BENEFITS: 4¢/KWH

INTEREST RATE: 6%



OPERATION & MAINTENANCE = 2% (TOTAL DIRECT COST
− COST OF CANAL RESTORAT

⇒ RESPONSIBILITY OF MAINTENANCE TO NASHUA RECREATION & PARKS (SEE SECT 8.1

= .02 ($2,656,000 − $400,000)
= $45,120

REVENUES = (7,220,000 KWH/YR)(4¢/KWH)
= $288,800/YR

PRESENT WORTH BENEFITS = $288,800 $(P/a)^{6\%}_{40}$
= $288,800 (15.046)
= $4,345,285

PRESENT WORTH COSTS = $3,357,000 + $45,120 $(P/a)^{6\%}_{40}$
= $3,357,000 + $678,875
= $4,035,875

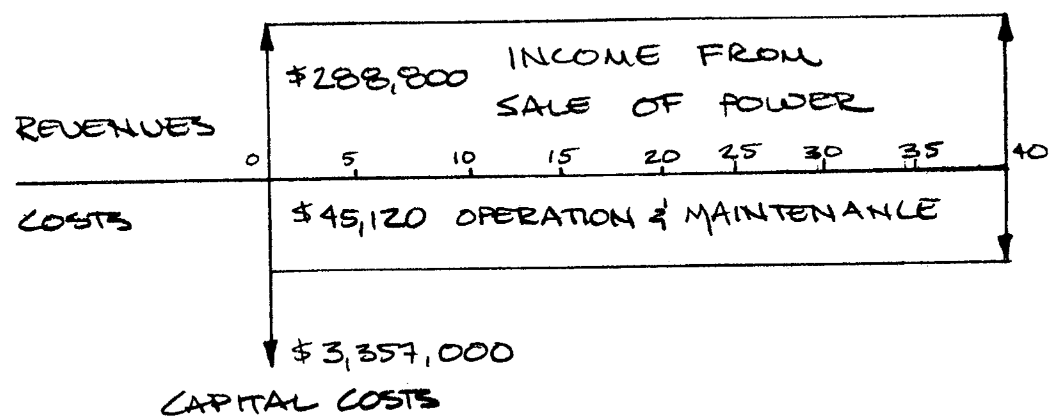
BENEFITS/COSTS = $\dfrac{\$4,345,284}{\$4,035,875}$ = 1.08

BENEFIT/COST ANALYSIS

COMPUTED KH
CHECKED SDM

MINE FALLS
PROJECT LIFE: 40 YEARS
INITIAL COST: \$3,357,000
ENERGY: 7,220,000 KWH/YR.
BENEFITS: 4¢/KWH

INTEREST RATE: 8%



OPERATION & MAINTENANCE = 2% (TOTAL DIRECT COST
− COST OF CANAL RESTORATION
⇒ RESPONSIBILITY OF MAINTENANCE TO
NASHUA RECREATION & PARKS (SEE SECT 8.1.1))
= .02 (\$2,656,000 − \$400,000)
= \$45,120

REVENUES = (7,220,000 KWH/YR)(4¢/KWH)
= \$288,800/YR

PRESENT WORTH BENEFITS = \$288,800 $(P/a)^{8\%}_{40}$
= \$288,800 (11.925)
= \$3,443,940

PRESENT WORTH COSTS = \$3,357,000 + \$45,120 $(P/a)^{8\%}_{40}$
= \$3,357,000 + \$538,056
= \$3,895,056

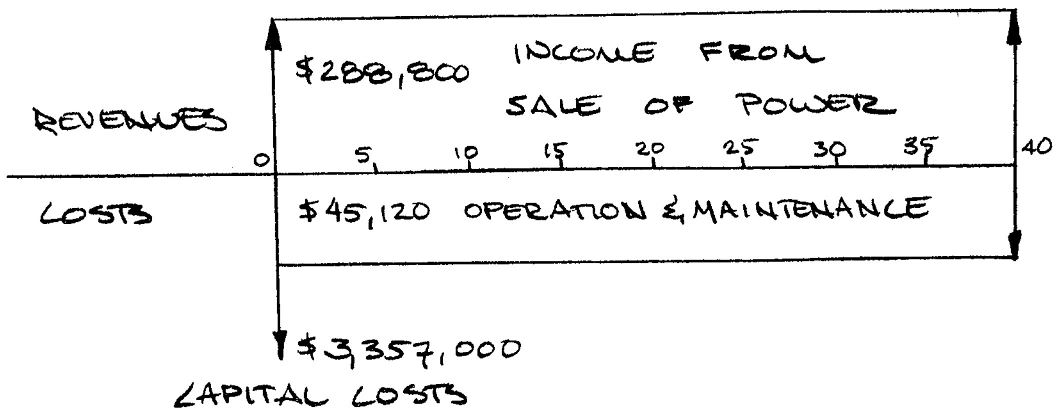
BENEFITS/COSTS = $\frac{\$3,443,940}{\$3,895,056}$ = 0.88

BENEFIT/COST ANALYSIS

COMPUTED K[illegible]
CHECKED SD[illegible]

MINE FALLS
PROJECT LIFE: 40 YEARS
INITIAL COST: $3,357,000
ENERGY: 7,220,000 KWH/YR.
BENEFITS: 4¢/KWH

INTEREST RATE: 10%



OPERATION & MAINTENANCE = 2% (TOTAL DIRECT COST − COST OF CANAL RESTORA[TION])

⇒ RESPONSIBILITY OF MAINTENANCE TO NASHUA RECREATION & PARKS (SEE SECT[ION]

= .02 ($2,656,000 − $400,000)

= $45,120

REVENUES = (7,220,000 KWH/YR)(4¢/KWH)

= $288,800/YR.

PRESENT WORTH BENEFITS = $ 288,800 $(P/a)^{10\%}_{40}$

= $ 288,800 (9.779)

= $ 2,824,175

PRESENT WORTH COSTS = $3,357,000 + $45,120 $(P/a)^{10\%}_{40}$

= $3,357,000 + $441,228

= $3,798,228

BENEFITS/COSTS = $\frac{\$2,824,175}{\$3,798,228}$ = 0.74

COMPUTED KH
CHECKED SDM

CASH FLOW WITH AMORTIZATION OF CAPITAL COST
(SEE SECT. 8.1.4)

JACKSON MILLS
PROJECT LIFE: 40 YEARS
INITIAL COST: $1,840,000
ENERGY: 5,450,000 KWH/YR
BENEFITS: 4¢/KWH

INTEREST RATE: 6%
20 YEAR BOND LIFE

EARS 1-20

COSTS: AMORTIZATION = $1,840,000 $(a/P)^{6\%}_{20}$

= $1,840,000 (.08718) = $ 160,411

OPERATION & MAINTENANCE

.02 ($1,410,000) = $ 28,200

TOTAL ANNUAL COST = 188,611

REVENUES:

(5,450,000 KWH/YR.)(4¢/KWH) = $ 218,000

NET CASH FLOW = $ 29,389 /YR.

EARS 21-40

COSTS:

OPERATION & MAINTENANCE

= .02 ($1,410,000) = $ 28,200

REVENUES:

(5,450,000 KWH/YR.)(4¢/KWH) = $ 218,000

NET CASH FLOW = 189,800/YR.

COMPUTE[R] CHECK[…]

CASH FLOW WITH AMORTIZATION OF CAPITAL COST
(SEE SECT. 8.1.4)

MINE FALLS
PROJECT LIFE: 40 YEARS
INITIAL COST: $3,357,000
ENERGY: 7,220,000 KWH/YR
BENEFITS: 4¢/KWH

INTEREST RATE: 6%
20 YEAR BOND LIFE

YEARS 1-20

COSTS: AMORTIZATION = $3,357,000 $(a/p)^{6\%}_{20}$
= $3,357,000 (.08718) = $292,6

OPERATION & MAINTENANCE
= .02($2,656,000-$400,000) = $ 45,1

TOTAL ANNUAL COST = $ 337,7

REVENUES:
(7,220,000 KWH/YR.)(4¢/KWH) = $288,8

NET CASH FLOW = $-48,98

YEARS 21-40

COSTS:
OPERATION & MAINTENANCE
= .02($2,656,000-$400,000) = $ 45,1

REVENUES:
(7,220,000 KWH/YR.)(4¢/KWH) = $288,8

NET CASH FLOW = $243,68

APPENDIX D - Regulatory and Licensing

Docket No. RM78-9

APPLICATION FOR SHORT-FORM LICENSE (MINOR)

1. Applicant's full name and address: ______________________

____
(Zip Code)

2. Location of Project:

State: ______________________ County: ________________

Nearest town: ________________ Water body: ____________

3. Project description and proposed mode of operation (reference to Exhibits K and L, as appropriate):

(continue on separate sheet, if necessary)

4. Lands of the United States affected (shown on Exhibit K)

	(Name)	(Acres)
a. National Forest	________________	________________
b. Indian Reservation	________________	________________
c. Public Lands Under Jurisdiction of	________________	________________
d. Other	________________	________________
e. Total U.S. Lands		________________

f. Check appropriate box:

/__/ Surveyed /__/ Unsurveyed land in public-land state:

(1) If surveyed land in public-land state provide the following:

Sections and subdivisions: ________________

Range ________________ Township: ____________

Principal base and meridian: ________________

(2) If unsurveyed or not in public-land state, see Item 8 of instructions: ________________

5. Purposes of project (use of power output, etc.)

6. Construction of the project is planned to start __________ it will be completed within ____months from the date of issuance of license.
7. List here and attach copies of State water permits or other permits obtained authorizing the use or diversion of water, or authorizing (check appropriate box):
   - /__/ the construction, operation, and maintenance
   - /__/ the operation and maintenance

   of the proposed project.
8. Attach an environmental report prepared in accordance with the requirements set forth in the <u>Instructions for Completing Application for Short-Form License (Minor)</u>, below.
9. Attach Exhibits K and L drawings.
10. State of ______________________________

    County of ______________________________ss:

____

____

______________________________,

being duly sworn, depose(s) and say(s) that the contents of this application are true to the best of _____knowledge or belief and that (check appropriate box)

/__/ _______ is (are) a citizen(s) of the United States

/__/ all members of the association are citizens of the United States

/__/ _______ is (are) the duly appointed agent(s) of the state (municipality)(corporation) **(association)**

and has (have) signed this application this ___ day of _______ 19___.

____

(Applicant(s))

Docket No. RM78-9

By ____

Subscribed and sworn to before me, a Notary Public of the State of ________________________, this ___ day of ________,

/SEAL/

____

(Notary Public)

Docket No. RM78-9

INSTRUCTIONS FOR COMPLETING APPLICATION FOR SHORT-FORM LICENSE (MINOR)

GENERAL

1. This application may be used if the proposed or existing project will have or has a total generating capacity of not more than 1,500 kW (2,000 horsepower). Advice regarding the proper procedure for filing should be requested from the Federal Energy Regulatory Commission in Washington, D. C.; or from one of the Commission's Regional Offices in Atlanta, Chicago, Fort Worth, New York, or San Francisco.

2. This application is to be completed and filed in an original and nine copies with the Federal Energy Regulatory Commission, 825 N. Capitol Street, N.E., Washington, D. C. 20426. Each of the original and the nine copies of the application is to be accompanied by:

   a. One copy each of Exhibits K and L described below.

   b. One copy each of a state water quality certificate pursuant to Section 401 of the Federal Water Pollution Control Act (or evidence that this certificate is not needed), and any water rights certificate or similar evidence required by state law relating to use or diversion of water. In lieu of submitting a copy of a Section 401 certificate (or other certificate), evidence that applications for these certificates have been filed with appropriate agencies, or that such certificates are not necessary, will be adequate to begin FERC processing of the application.

   c. One copy each of any other state approvals necessary. (Applicant should contact the state natural resources department or equivalent to ascertain whether any such approvals are necessary.)

d. One copy of Applicant's environmental report, described below.

3. Applicant is required to consult with appropriate Federal, State, and local resources agencies during the preparation of the application and provide interested agencies with the opportunity to comment on the proposal prior to its filing with the Commission. The comments of such agencies must be attached to the application when filed. A list of agencies to be consulted can be obtained from the Commission's main office or the appropriate regional office.

4. No work may be started on the project until receipt of a signed license from the Commission. The application itself does not authorize entry upon Federal land for any purpose. If the project is located in part or in whole upon Federal land, the Applicant should contact the appropriate land management agency regarding the need to obtain a right-of-way permit. As noted above, other state or Federal permits may be required.

5. An applicant must be: a citizen or association of citizens of the United States; a corporation organized under the laws of the United States or a State; a State; or a municipality.

(a) If the applicant is a natural person, include an affidavit of United States citizenship.

(b) If the applicant is an association, include one verified copy of its articles of association. If there are no articles of association, that fact shall be stated over the signature of each member of the association. Also include a complete list of members and a statement of the citizenship of each in an affidavit by one of them.

(c) If the applicant is a corporation, include one copy of the charter or certificate and articles of incorporation, with all the amendments, duly certified by the secretary of state of the State where organized, and one copy of the by-laws. If the project is located in a state other than that in which the corporation is organized, include a certificate from the secretary of state of the State in which the project is located showing compliance with the laws relating to foreign corporations.

(d) If the applicant is a state, include a copy of the laws under the authority of which the application is made.

(e) If the applicant is a municipality as defined in the Federal Power Act, include one copy of its charter or other organization papers, duly certified by the secretary of state of the State in which it is located, or other proper authority. Also include a copy of the State laws authorizing the operations contemplated by the application.

Include a copy of all minutes, resolutions of stockholders or directors, or other representatives of the applicant, properly attested, authorizing the filing of the application. This information can be provided by a letter attached to the application.

6. If the stream or water body is unnamed, give the name of the nearest named stream or water body to which it is tributary.

7. The project description (application item 3) shall include, as appropriate: the number of generating units, including auxiliary units, the capacity of each unit, and provisions, if any, for future units; type of hydraulic turbine(s); a description of how the plant is to be operated, manual or automatic, and whether the plant is to be used for peaking; estimated average annual generation in kilowatt-hours or mechanical energy equivalent; estimated average head on the plant; reservoir surface area in acres and, if known, the net and gross storage capacity; estimated hydraulic capacity of the plant (flow through the plant) in cubic feet per second; estimated average flow of the stream or water body at the plant or point of diversion; sizes, capacities, and construction materials, as appropriate, of pipelines, ditches, flumes, canals, intake facilities, powerhouses, dams, transmission lines, etc.; and estimated cost of the project.

8. In the case of unsurveyed public land, or land not in a public-lands state, give the best legal description available. Include the distance and general direction from the nearest city or town, fixed monument, physical features, etc.

9. Exhibits K and L shall be submitted on separate drawings. Drawings for Exhibits K and L shall have identifying title blocks and bear the following certification: "This drawing is a part of the application for license made by the undersigned this ____ day of ________________, 19____.

________________________"

(Name of Applicant)

10. The Commission reserves the right to require additional information, or another filing procedure, if data provided indicate such action to be appropriate.

EXHIBIT K-PROJECT LANDS AND BOUNDARIES

1. The Exhibit K is a planimetric map showing the portion of the stream developed, the location of all project works, and other important features, such as: the dam or diversion structure, reservoir pipeline, powerplant, access roads, transmission lines, project boundary, private land ownerships (clearly differentiate between fee ownership and land over which applicant only owns an easement), and Federal land boundaries and identifications.

2. The map shall be an ink drawing or drawing of similar quality on a sheet not smaller than 8 inches by 10-1/2 inches, drawn to a scale no smaller than one inch equals 1,000 feet. Ten legible prints shall be sumbitted with the application. Upon request after review of the application, the tracing must be submitted.

3. The project boundary shall be drawn on the map so that the relationship of each project facility and reservoir to other property lines can be determined. The boundary shall enclose all project works, such as the dam, reservoir, pipelines, roads, powerhouse, and transmission lines. The boundary shall be set at the minimum feasible distance from project works necessary to allow operation and maintenance of the project and control of the shoreline and reservoir. The distance in feet from each principle facility to the boundary shall be shown. The project boundary should be a surveyed line with stated courses and distances. A tape compass survey is acceptable. True north shall be indicated on the map.

The area of Federal land in acres within the project boundary shall be shown. The appropriate Federal agency should be contacted for assistance in determining the Federal land acreage. For clarity, use inset sketches to a larger scale than that used for the overall map to show relationships of project works, natural features, and property lines.

4. Show one or more ties by distance and bearing from a definite, identifiable point or points on project works or the project boundary to established corners of the public land survey or other survey monuments, if available.

5. If the project affects unsurveyed Federal lands, the protraction of township and section lines shall be shown. Such protractions, whenever available, shall be those recognized by the agency of the United States having jurisdiction over the lands. On unsurveyed lands, show ties by distance and bearing to fixed recognizable objects.

6. If the project uses both Federal and private lands, the detailed survey descriptions discussed above for the project boundary apply only to Federal lands. General location data and an approximate project boundary will normally suffice for project works on private lands.

EXHIBIT L-PROJECT STRUCTURES AND EQUIPMENT

1. The exhibit shall be a simple ink drawing or drawing of similar quality on a sheet no smaller than 8 inches by 10-1/2 inches, drawn to a scale no smaller than one inch equals 50 feet for plans and profiles, and one inch equals 10 feet for sections. Ten legible prints shall be submitted with the application. Upon request after initial review of the application, tracings must be submitted.

2. The drawing shall show a plan, elevation, and section of the diversion structure and powerplant. Generating and auxiliary equipment proposed should be clearly and simply depicted and described. Include a north arrow on the plan view.

ENVIRONMENTAL REPORT

The environmental report should be consistent with the scope of the project and the environmental impacts of the proposed action; e.g., authorization to operate and maintain an existing project, or a project using an existing dam or other facility, would require less detailed information than authorization to construct a new project. The environmental report shall set forth in a clear and concise manner:

(1) A brief description of the project and the mode of operation, i.e., run-of-river, peaking or other specific mode.

(2) A description of the environmental setting in and near the project area, to include vegetative cover, fish and wildlife resources, water quality and quantity, land and water uses, recreational use, socio-economic aspects, historical and archeological resources, and visual resources. Special attention shall be provided endangered and threatened plant and animal species, critical habitats, and sites eligible for or included on the National Register of Historic Places. Assistance in the preparation of this information may be obtained from state natural resources departments and from local offices of Federal natural resources agencies.

(3) A description of the expected environmental impacts resulting from the continued operation of an existing project, or from the construction and operation of a new project or a project using an existing dam or other existing facility. Include a discussion of specific measures proposed by the Applicant and others to protect and enhance environmental resources and to mitigate adverse impacts of the project on the environmental resources and values, the cost of those measures, and the party undertaking to implement those measures if other than the Applicant.

(4) A description of alternative means of obtaining an amount of power equivalent to that provided by the project in the event that construction or continued operation of the project is not authorized.

(5) A description of the steps taken by the Applicant in consulting with Federal, state, and local agencies during the preparation of the environmental report. Indicate which agencies have received the final report and provide copies of letters containing the comments of those agencies.

by the
FEDERAL ENERGY REGULATORY COMMISSION REGULATION[1]

(1.) Excerpted from "(Draft) Federal Legal Obstacles and Incentives to the Development of the Small Scale Hydroelectric Potential of the Nineteen Northeastern United States" by the Energy Law Institute, Franklin Pierce Law Center, Concord, New Hampshire.
Anderson-Nichols & Company, Inc. is solely responsible for its interpretation as presented herein.

HYDROELECTRIC PROJECT

↓

File: Declaration of Intent to allow F.E.R.C. to determine jurisdiction
- mandatory for all new projects

↓

Is project under F.E.R.C. jurisdiction?
- Is project located on or does it affect navigable waterway?
- Is project connected to interstate grid?

↓

YES → Comply with state and local requirements
See flow diagram for State Regulations

↓

File: Preliminary Permit Application
- preference to public entities

↓

permit granted (or permit process bypassed)

↓

Prepare F.E.R.C. license application if project will generate less than 1.5 mw.

→ Prepare Short Form (minor) License
-secure data
-briefly describe environmental impact, and

↓

-acquire land water rights
-sign contract for sale of power
-consult with Fish & Wildlife agencies
-consult with Historical & Archeological Preservation agencies
-consult list of Endangered Species
-consult Wild & Scenic Rivers designations
-consult National Trails System
-obtain S 404 dredge and fill permit
-obtain S 401 state water quality certification and other state permits

See flow diagram for State Regulations

↓

File: License application with F.E.R.C. which review for deficiencies

↓

Accepted and Docketed

↓

F.E.R.C. begins processing license application

↓

Application section appoints project manager, reviews for general adequacy

↓

Environmental analysis section reviews impact, decides if EIS required

→ No EIS required for minor ($<$ 1.5 mw) projects (negative determination prepared)

↓

Project Manager receives comments by F.E.R.C. office on application

↓

Project Manager prepares Power Memorandum
-Office of General Council prepares Commission Order

↓

Commissioners receive Power Memorandum, final EIS, Commission Order

↓

Commission Acts on License application
-is the project that best adapted to the comprehensive development of the waterway
-is the project best developed by the Federal government?
-is the project in the public interest?

→ APPROVED

FLOW DIAGRAM FOR THE FEDERAL REGULATIONS

Anderson-Nichols & Co., Inc. Concord New Hampshire	U.S. Army Engineer Div. New England Corps of Engineers Waltham, MA

FEDERAL REGULATION OF SMALL DAMS by the FEDERAL ENERGY REGULATORY COMMISSION REGULATION[1]

(1.) Excerpted from "(Draft) Federal Legal Obstacles and Incentives to the Development of the Small Scale Hydroelectric Potential of the Nineteen Northeastern United States" by the Energy Law Institute, Franklin Pierce Law Center, Concord, New Hampshire.
Anderson-Nichols & Company, Inc. is solely responsible for its interpretation as presented herein.

HYDROELECTRIC PROJECT

File: Declaration of Intent to allow F.E.R.C. to determine jurisdiction
- mandatory for all new projects

Is project under F.E.R.C. jurisdiction?
- Is project located on or does it affect navigable waterway?
- Is project connected to interstate grid?

YES

Comply with state and local requirements
See flow diagram for State Regulations

File: Preliminary Permit Application
- preference to public entities

permit granted (or permit process bypassed)

Prepare F.E.R.C. license application if project will generate less than 1.5 mw.

Prepare Short Form (minor) License
-secure data
-briefly describe environmental impact, and

-acquire land water rights
-sign contract for sale of power
-consult with Fish & Wildlife agencies
-consult with Historical & Archeological Preservation agencies
-consult list of Endangered Species
-consult Wild & Scenic Rivers designations
-consult National Trails System
-obtain S 404 dredge and fill permit
-obtain S 401 state water quality certification and other state permits

See flow diagram for State Regulations

File: License application with F.E.R.C. which review for deficiencies

Accepted and Docketed

F.E.R.C. begins processing license application

Application section appoints project manager, reviews for general adequacy

Environmental analysis section reviews impact, decides if EIS required

No EIS required for minor ($<$ 1.5 mw) projects (negative determination prepared)

Project Manager receives comments by F.E.R.C. office on application

Project Manager prepares Power Memorandum
-Office of General Council prepares Commission Order

Commissioners receive Power Memorandum, final EIS, Commission Order

Commission Acts on License application
-is the project that best adapted to the comprehensive development of the waterway
-is the project best developed by the Federal government?
-is the project in the public interest?

APPROVED

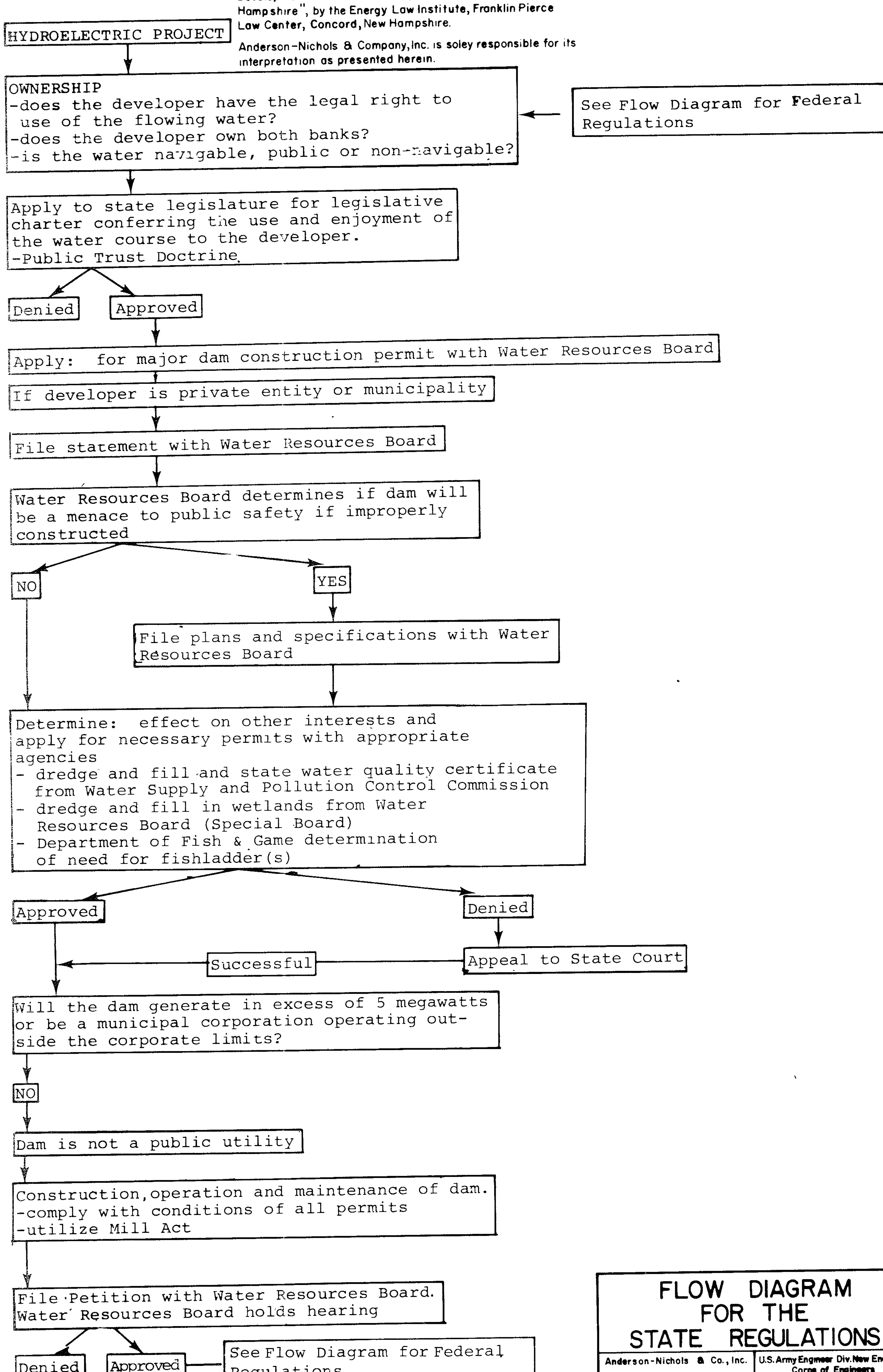
FLOW DIAGRAM FOR THE FEDERAL REGULATIONS

Anderson-Nichols & Co., Inc. Concord New Hampshire	U.S. Army Engineer Div. New England Corps of Engineers Waltham, MA

REGULATION OF SMALL DAMS IN NEW HAMPSHIRE (I.)
as applies to
FEASIBILITY OF MINE FALLS DAM AND JACKSON **MILLS** DAM

(I.) Excerpted from "Legal Obstacles and Incentives to the Development of Small Scale Hydroelectric Power in New Hampshire", by the Energy Law Institute, Franklin Pierce Law Center, Concord, New Hampshire.

Anderson-Nichols & Company, Inc. is soley responsible for its interpretation as presented herein.



FLOW DIAGRAM FOR THE STATE REGULATIONS

Anderson-Nichols & Co., Inc.
Concord New Hampshire

U.S. Army Engineer Div. New England
Corps of Engineers
Waltham, MA

GENERAL DEFINITIONS AND TERMS

Federal Energy Regulatory Commission: (FERC) The primary Federal agency involved in the regulation of hydroelectric dams. The Commission regulates the construction and operation of hydroelectric dams under Part I of the Federal Power Act and the sale of electricity in interstate commerce under Part II of the Act. The FERC has jurisdiction over four varieties of hydroelectric development 1) projects located on navigable waterways, 2) projects affecting interstate commerce either by affecting a navigable waterway (if the proposed project is on a non-navigable waterway) or if the projects are connected to an interstate grid, 3) projects which utilize federal land, 4) projects which utilize surplus water from government dams.

Declaration of Intent: A letter from the hydroelectric developer to the FERC and required by the Federal Power Act describing briefly the proposed project. This letter begins the FERC involvement with jurisdiction over the project.

Federal Power Act: Legislation enacted in 1905 giving the Forest Service, within the Department of Agriculture, the authority to set "A reasonable charge for any permit, right or privilege, so long as such charge is not inconsistent with the purposes for which the Reserves were created". For water power development, the charge was based on the horsepower developed at the wheel.

eminent domain: the right or power of the state to take private property for public use, or to control its use, usually at an adequate compensation.

Mill Dam Act: The New Hampshire law which applies to "mills" which include manufacturing plants and plants at which electric power is generated for public distribution or for the operation of mills or public utilities.

Riparian law: In New Hampshire where the developer's land borde upon a stream, his ownership will include the bed of the stream to its thread. The ownership of the land bordering the stream gives the developer ownership of the right to use the water, not owne ship of the water. This may be contrasted to the Western Riparian law under which the right to use flowing water accrues in the first user rather th the Riparian or bordering owner.

Public Trust Law: In New Hampshire it is the duty the state owes to the public in its administration of the public resources. The developer must seek permission of the people, through the state legislature for use of the public resources. When a stream is capabl in its natural state of some useful service to th public because of its existence as such it is pul

Public Utilities Commission: In New Hampshire the state agency which oversees that adequate utility service is provided at fair and reasonable rates. The commission is an arm of the State Legislature and has the power to establish utility rates, audit utilities through financial reports, establish service territories for utilities and set standards of service for utilities.

Water Resources Board: In New Hampshire a state board established to oversee the conservation of water, the control of discharges from dams and all public water related projects. The Water Resources Board is also concerned with the registration of dams and will determine if the dam is a menace to public safety.

Special Board: In New Hampshire Water Resources Board a committee which issues permits pertaining to dredging a watercourse for the purpose of increasing the depth of the impoundment area or filling to insure structural stability before construction. The Special Board includes members of the Water Resources Board, Fish and Game, and the Water Supply and Pollution Control Commission.

Preliminary Permit Application: A permit application submitted to the FERC by the hydroelectric developer. The purpose of the preliminary permit is to maintain a priority of application for the particular project and to allow the developer to invest funds necessary to file a complete and adequate license application without risk of loss of the site to another developer. The Commission must give preference in awarding preliminary permits to state or municipal applicants thereby giving public entities a significant advantage over private applicants. The application requires the name, location and description of the project, locati maps, explanation of the proposed use of power and any further dat the FERC may consider pertinent upon receipt of the permit applica

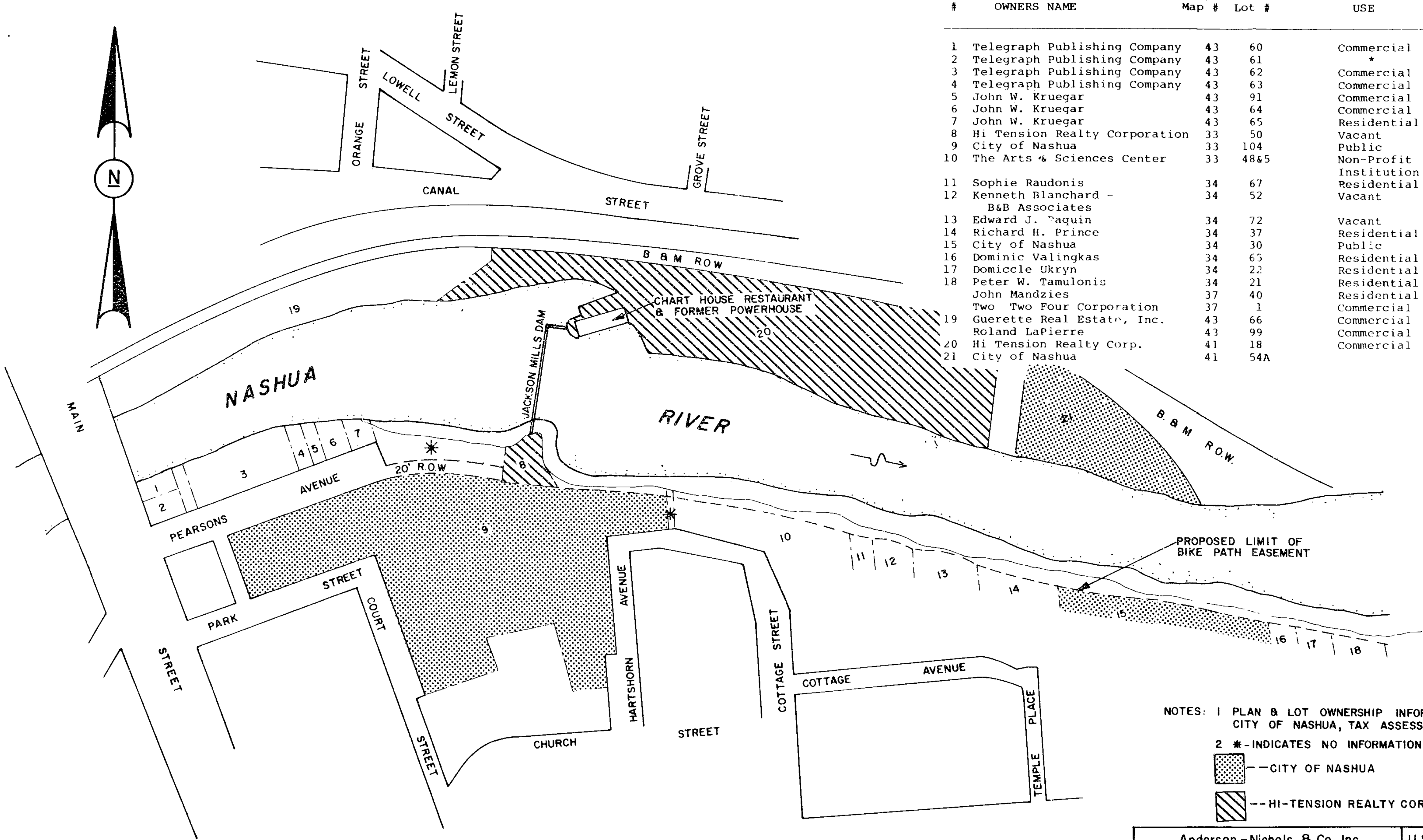
License Application: The issuance of licenses requires a procedur which is an amplification of the preliminary permit process. The FERC issues two types of licenses: one for projects of less than 1.5 mw in capacity (minor project) and one for large projects (major project).

Major Project License: An application must be filed for a project of more than 1.5 mw capacity. The applicant must have completed all preconstruction activity prior to filing the application. Thi activity includes performance of feasibility studies, procuring land and water rights, obtaining state permits, completing design work and selecting equipment.

Minor Project License "Short Form": filed with the FERC and requires the same information required for the preliminary permit as well as evidence of compliance with state water quality laws and the state requirements, a brief description of the environmental impact of the project and comments from Federal agencies which were consulted prior to submittal. The advantage of the minor project application is that it does not require the preparation of an environemntal impact statement. The effect of the short form application is to require the applicant to consult with state and federal agencies to iron out problems with the project prior to filing the application.

APPENDIX E - Plates

LOT #	OWNERS NAME	ASSESSOR'S Map #	ASSESSOR'S Lot #	USE	REMARKS
1	Telegraph Publishing Company	43	60	Commercial	
2	Telegraph Publishing Company	43	61	*	
3	Telegraph Publishing Company	43	62	Commercial	
4	Telegraph Publishing Company	43	63	Commercial	
5	John W. Kruegar	43	91	Commercial	
6	John W. Kruegar	43	64	Commercial	
7	John W. Kruegar	43	65	Residential	
8	Hi Tension Realty Corporation	33	50	Vacant	C/O Sanders Associates
9	City of Nashua	33	104	Public	Library
10	The Arts & Sciences Center	33	48&5	Non-Profit Institution	
11	Sophie Raudonis	34	67	Residential	
12	Kenneth Blanchard - B&B Associates	34	52	Vacant	
13	Edward J. Paquin	34	72	Vacant	
14	Richard H. Prince	34	37	Residential	
15	City of Nashua	34	30	Public	
16	Dominic Valingkas	34	65	Residential	
17	Domiccle Ukryn	34	22	Residential	
18	Peter W. Tamulonis	34	21	Residential	
	John Mandzies	37	40	Residential	
	Two Two Four Corporation	37	1	Commercial	
19	Guerette Real Estate, Inc.	43	66	Commercial	
	Roland LaPierre	43	99	Commercial	
20	Hi Tension Realty Corp.	41	18	Commercial	C/O Sanders Associates
21	City of Nashua	41	54A		City Snow Dump



NOTES: 1 PLAN & LOT OWNERSHIP INFORMATION FROM CITY OF NASHUA, TAX ASSESSORS OFFICE, APRIL, 1979

2 *-INDICATES NO INFORMATION AVAILABLE

--CITY OF NASHUA

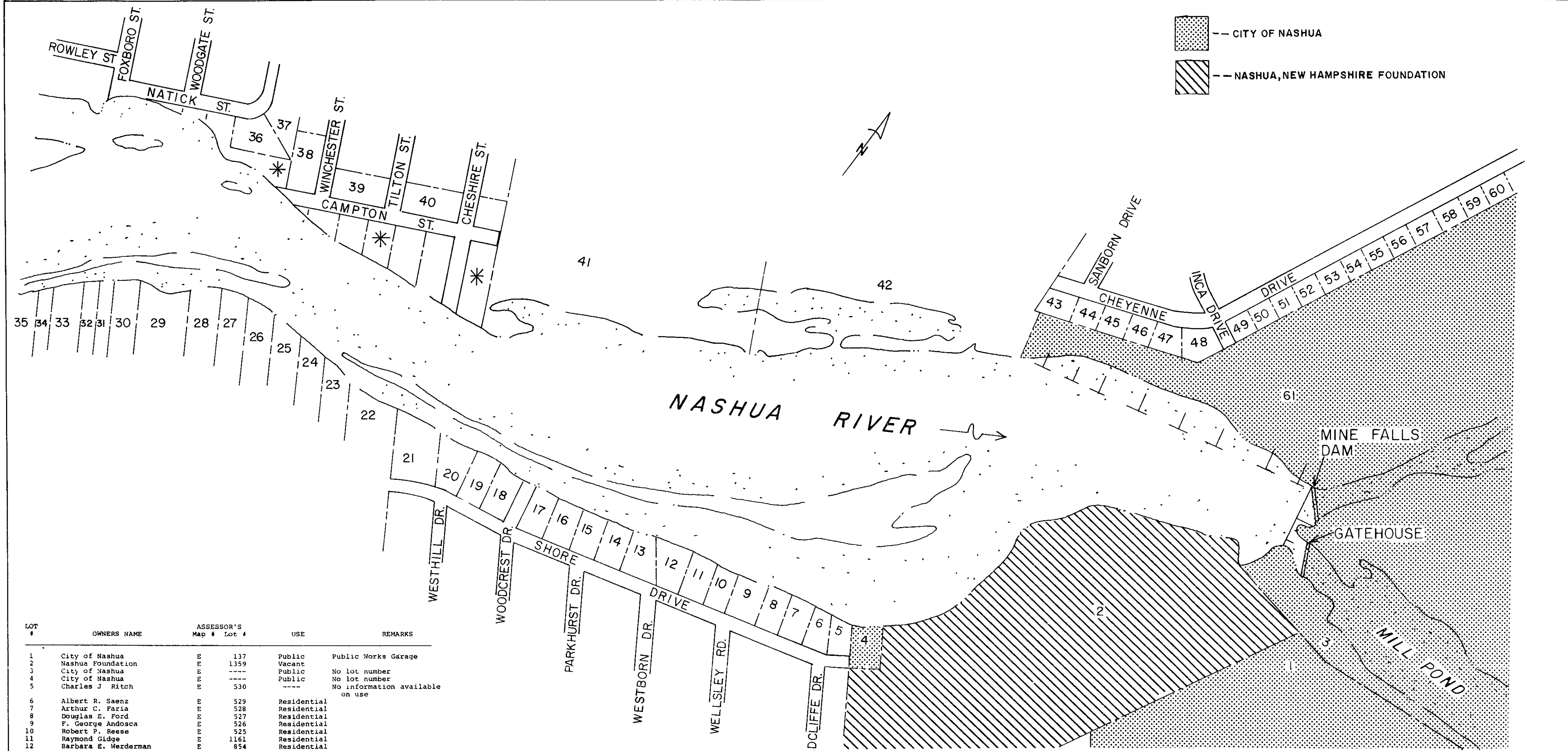
--HI-TENSION REALTY CORPORATION

Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE	U.S ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S.-14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
JACKSON MILLS DAM
PLAN OF ABUTTING LAND

SCALE: NOT TO SCALE
DATE: MAY, 1979

PLATE I



LOT #	OWNERS NAME	ASSESSOR'S Map #	ASSESSOR'S Lot #	USE	REMARKS
1	City of Nashua	E	137	Public	Public Works Garage
2	Nashua Foundation	E	1359	Vacant	
3	City of Nashua	E	----	Public	No lot number
4	City of Nashua	E	----	Public	No lot number
5	Charles J Ritch	E	530	----	No information available on use
6	Albert R. Saenz	E	529	Residential	
7	Arthur C. Faria	E	528	Residential	
8	Douglas E. Ford	E	527	Residential	
9	F. George Andosca	E	526	Residential	
10	Robert P. Reese	E	525	Residential	
11	Raymond Gidge	E	1161	Residential	
12	Barbara E. Werderman	E	854	Residential	
13	James C. Crawford	E	853	Residential	
14	Walter J Barry	E	852	Residential	
15	Vivian J. St Laurent	E	887	Residential	
16	Barry J Palmer	E	969	Residential	
17	David D. Lozeau	E	998	Residential	
18	James M. Addonizio	E	1156	Residential	
19	Paul C. Coppens	E	1155	Residential	
20	James T. Garasky	E	1154	Residential	
21	Edward F. Kelly	E	1153	Residential	
22	Sterling-Warner Industrial Investment Corporation	F	67	Residential	
23	Sterling-Warner Industrial Investment Corporation	F	68	Residential	
24	William G. Robbins	F	66	Commercial	Camp
25	William G. Robbins	F	65	Commercial	Camp
26	Nina K. Pitarys	F	64	Residential	
27	Eunice E. Roy	F	63	Residential	
28	Eunice E. Roy	F	62	Residential	
29	Pitarys Homes Inc.	F	61	Vacant	
30	Reginald G. Walker	F	60	Residential	
31	Reginald G. Walker	F	59	Residential	
32	Albert J. Levesque	F	70	----	No info available on use
33	Albert J. Levesque	F	58	Residential	
34	Albert J. Levesque	F	57	Vacant	
35	Wilfred O. Dupont	F	56	Residential	
36	Howard Rainey	F	255	Residential	
37	------------	F	258	----	No info available on owner or use
38	Fred D. Tirrel & Nicholas E. Zamposi	F	786	Residential	
39	Fred D. Tirrel & Nicholas E. Zamposi	F	788	Residential	
40	Fred D. Tirrel & Nicholas E. Zamposi	F	787	Residential	

LOT #	OWNERS NAME	ASSESSOR'S Map #	ASSESSOR'S Lot #	USE	REMARKS
41	A. Jasalavich	F	6	Residential	
42	Nashua Sand & Gravel	F	7	Commercial	
43	Marcel Trepanier	E	1176	Residential	
44	Fredrick Lozier	E	1175	Residential	
45	William R. Neville	E	1174	Residential	
46	Robert Robinson	E	1173	Residential	
47	John H. Hoffman	E	1172	Residential	
48	Edward C Gassman	E	1171	Residential	
49	Thomas E. Williams	E	1170	Residential	
50	Steven J Salvi	E	1169	Residential	
51	Loring E Clark	E	1168	Residential	
52	Gunnar I. Kahlke	E	1167	----	No info available on use
53	Ricard I. Grohosky	E	1166	Residential	
54	Anthony Storace	E	1165	Residential	
55	Andre J Duquette	E	1164	Residential	
56	Michael C. Towle	E	1163	Residential	
57	George W. Preston	E	1162	Residential	
58	Guy P. Riendean	E	1214	Residential	
59	Robert B. Masek	E	1213	Residential	
60	Richard A Newell	E	878	Residential	
61	City of Nashua	F	----	Public	No lot number

NOTES: 1 PLAN & LOT OWNERSHIP INFORMATION FROM CITY OF NASHUA TAX ASSESSORS OFFICE, APRIL 1979

2 * INDICATES NO INFORMATION AVAILABLE

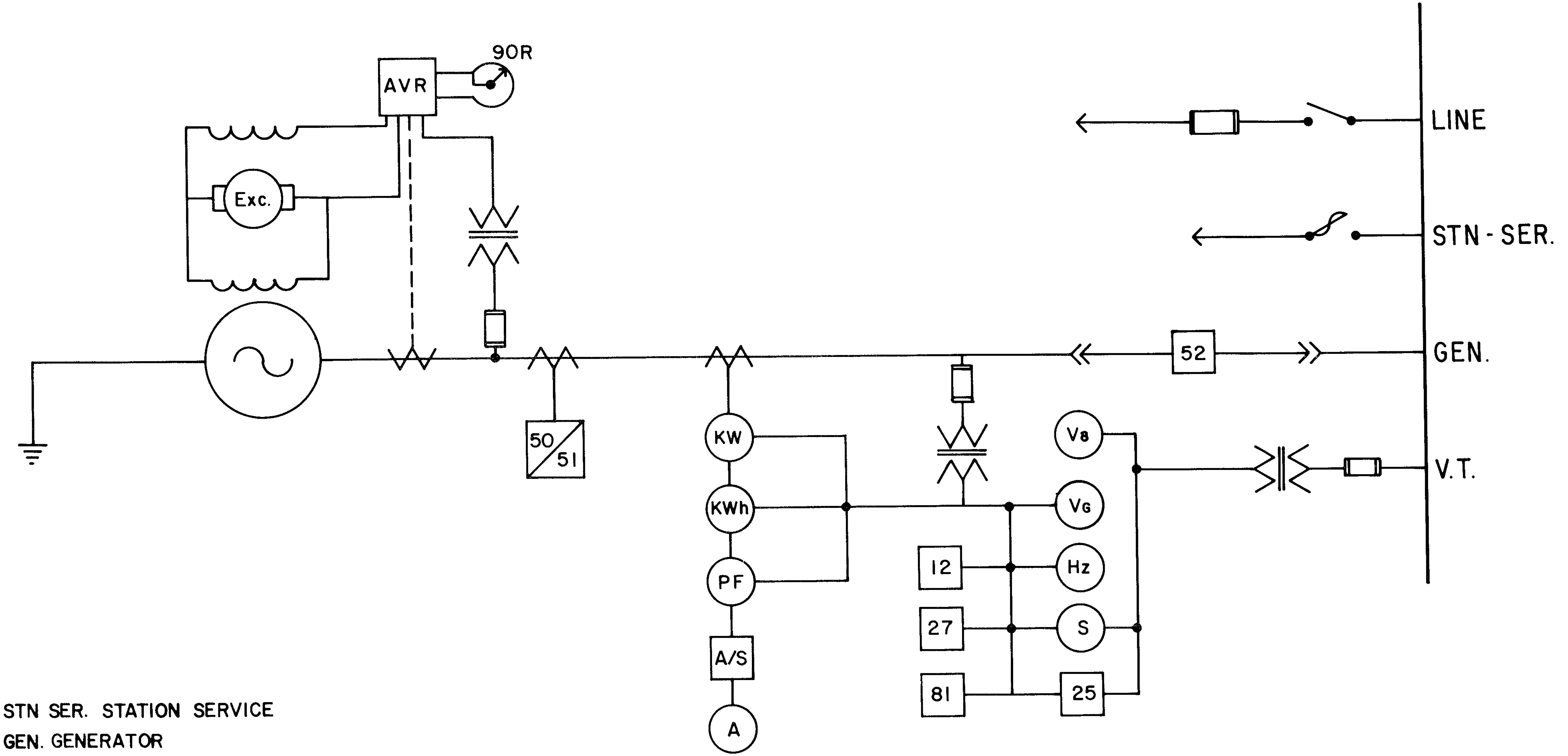
Anderson-Nichols & Co., Inc.
CONCORD NEW HAMPSHIRE

U.S ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MA

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S - 14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
MINE FALLS DAM
PLAN OF ABUTTING LAND

SCALE: NOT TO SCALE
DATE: MAY, 1979

PLATE 2



STN SER. STATION SERVICE
GEN. GENERATOR
V.T. VOLTAGE TRANSFORMER
12 OVERSPEED RELAY
13 SPEED RELAY
27 BUS VOLTAGE RELAY
51 OVERCURRENT RELAY
64N NEUTRAL OVERCURRENT RELAY
52 CIRCUIT BREAKER
89 CAPACITOR DISCONNECT/ GROUNDING SWITCH

81 UNDERFREQUENCY RELAY
A AMMETER
A/S AMMETER SWITCH
Hz FREQUENCY INDICATOR
KW KW INDICATOR
KWh KWh METER
T/G TACH GENERATOR
V VOLTMETER

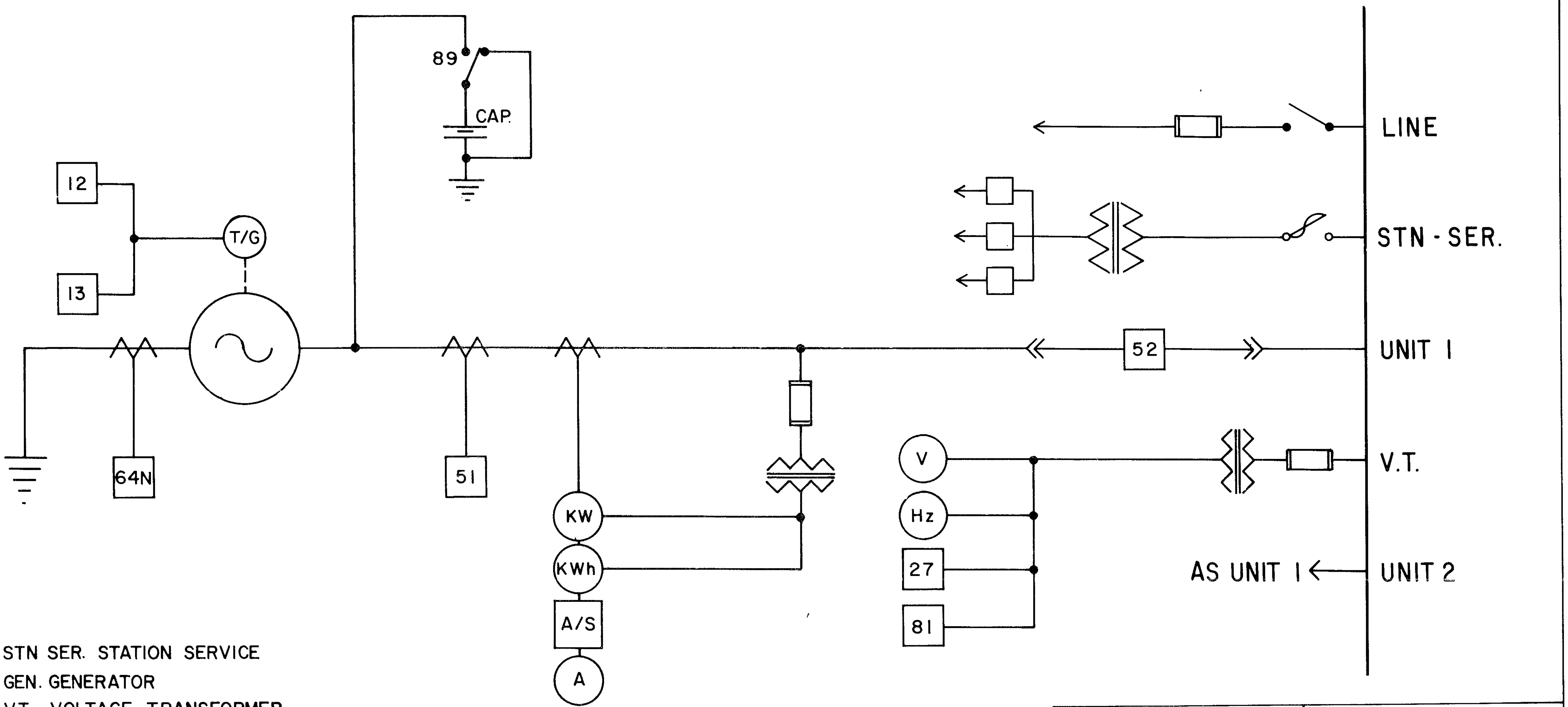
Anderson-Nichols & Co., Inc.
CONCORD NEW HAMPSHIRE

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MA

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S.-14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
SINGLE LINE DIAGRAM
SYNCHRONUS GENERATOR

SCALE: NOT TO SCALE
DATE: MAY, 1979

PLATE 3



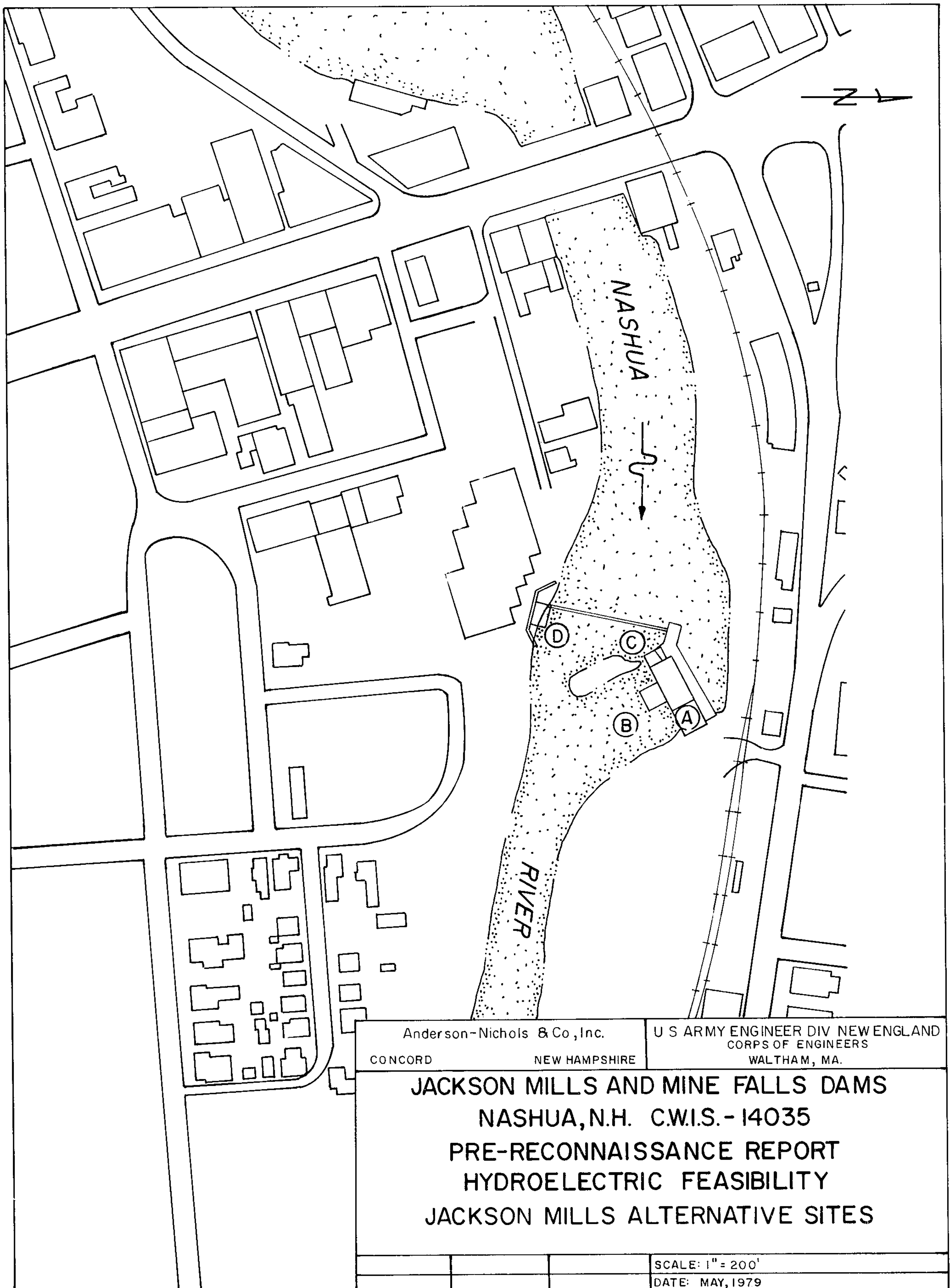
STN SER. STATION SERVICE
GEN. GENERATOR
V.T. VOLTAGE TRANSFORMER
12 OVERSPEED RELAY
13 SPEED RELAY
27 BUS VOLTAGE RELAY
51 OVERCURRENT RELAY
64N NEUTRAL OVERCURRENT RELAY
52 CIRCUIT BREAKER
89 CAPACITOR DISCONNECT/ GROUNDING SWITCH

81 UNDERFREQUENCY RELAY
A AMMETER
A/S AMMETER SWITCH
Hz FREQUENCY INDICATOR
KW KW INDICATOR
KWh KWh METER
T/G TACH GENERATOR
V VOLTMETER

Anderson-Nichols & Co, Inc CONCORD NEW HAMPSHIRE	U S ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S.- 14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
SINGLE LINE DIAGRAM
INDUCTION GENERATOR

SCALE: NOT TO SCALE
DATE: MAY, 1979



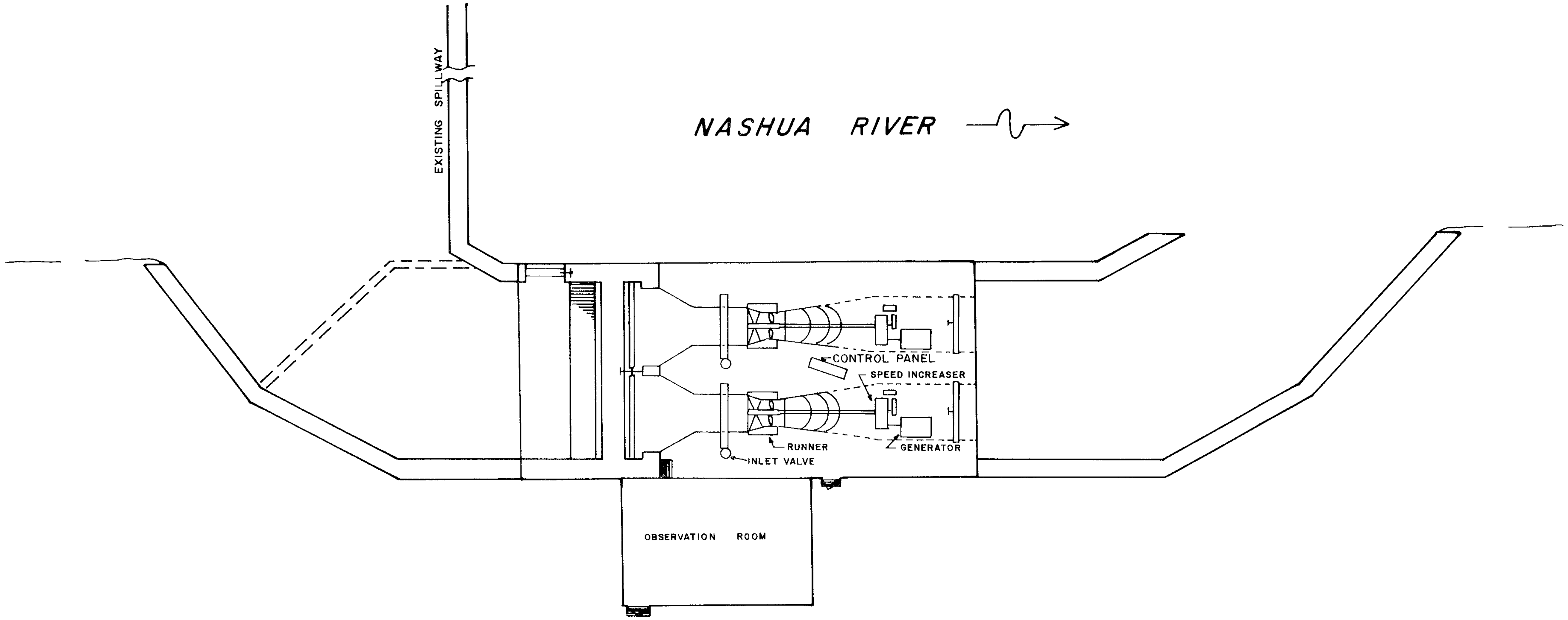
Anderson-Nichols & Co, Inc.
CONCORD NEW HAMPSHIRE

U S ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MA.

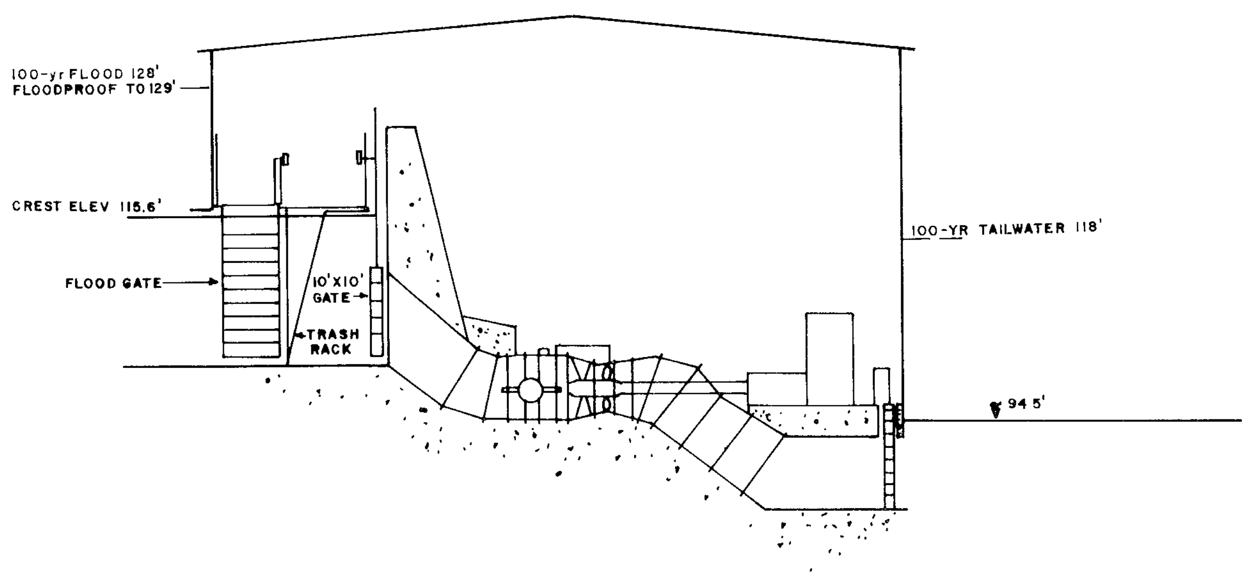
JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S.-14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
JACKSON MILLS ALTERNATIVE SITES

SCALE: 1" = 200'
DATE: MAY, 1979

PLATE 5



PLAN



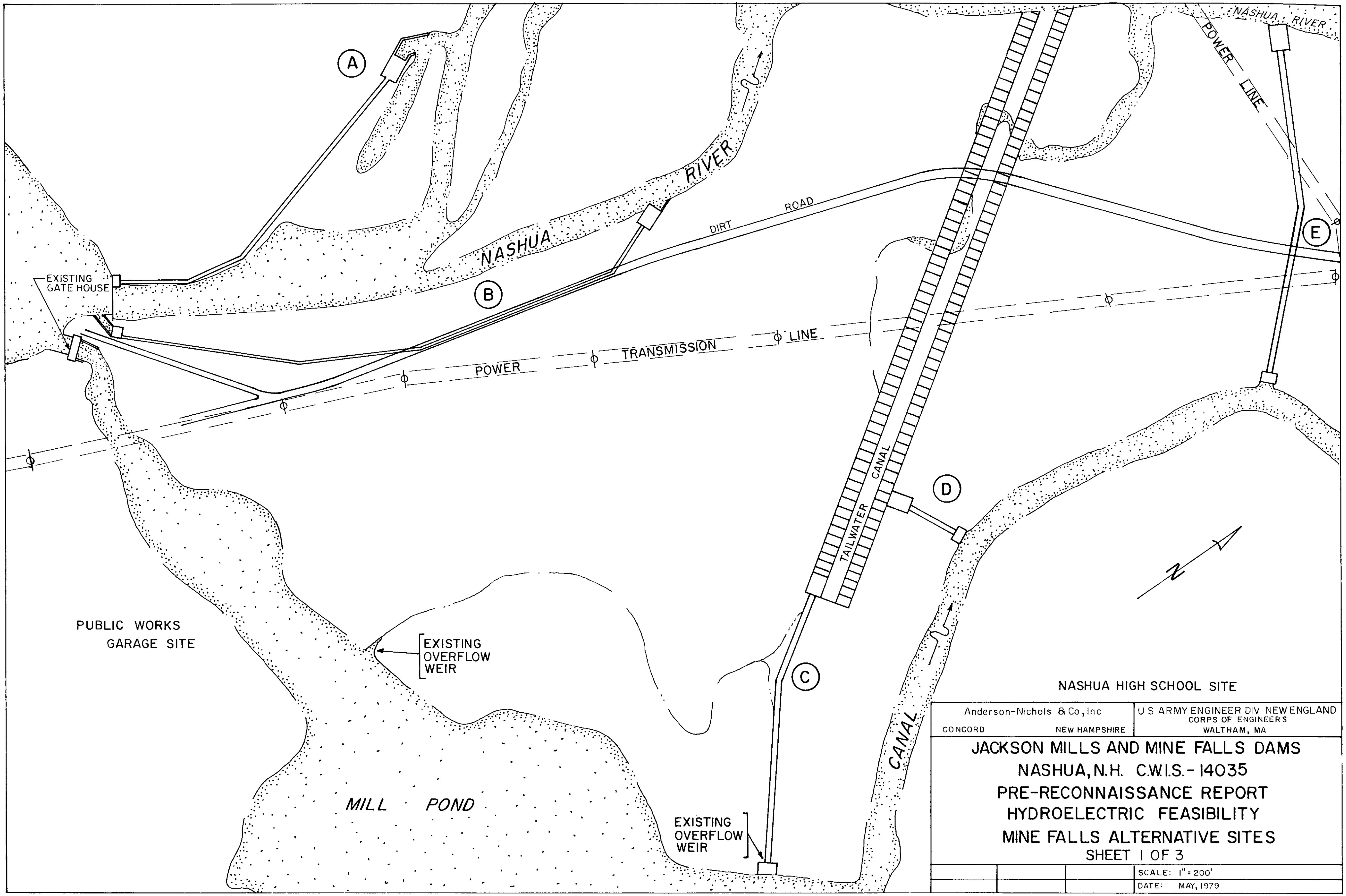
PROFILE

Anderson-Nichols & Co., Inc CONCORD NEW HAMPSHIRE	U S ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA.

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S. - 14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
JACKSON MILLS SITE

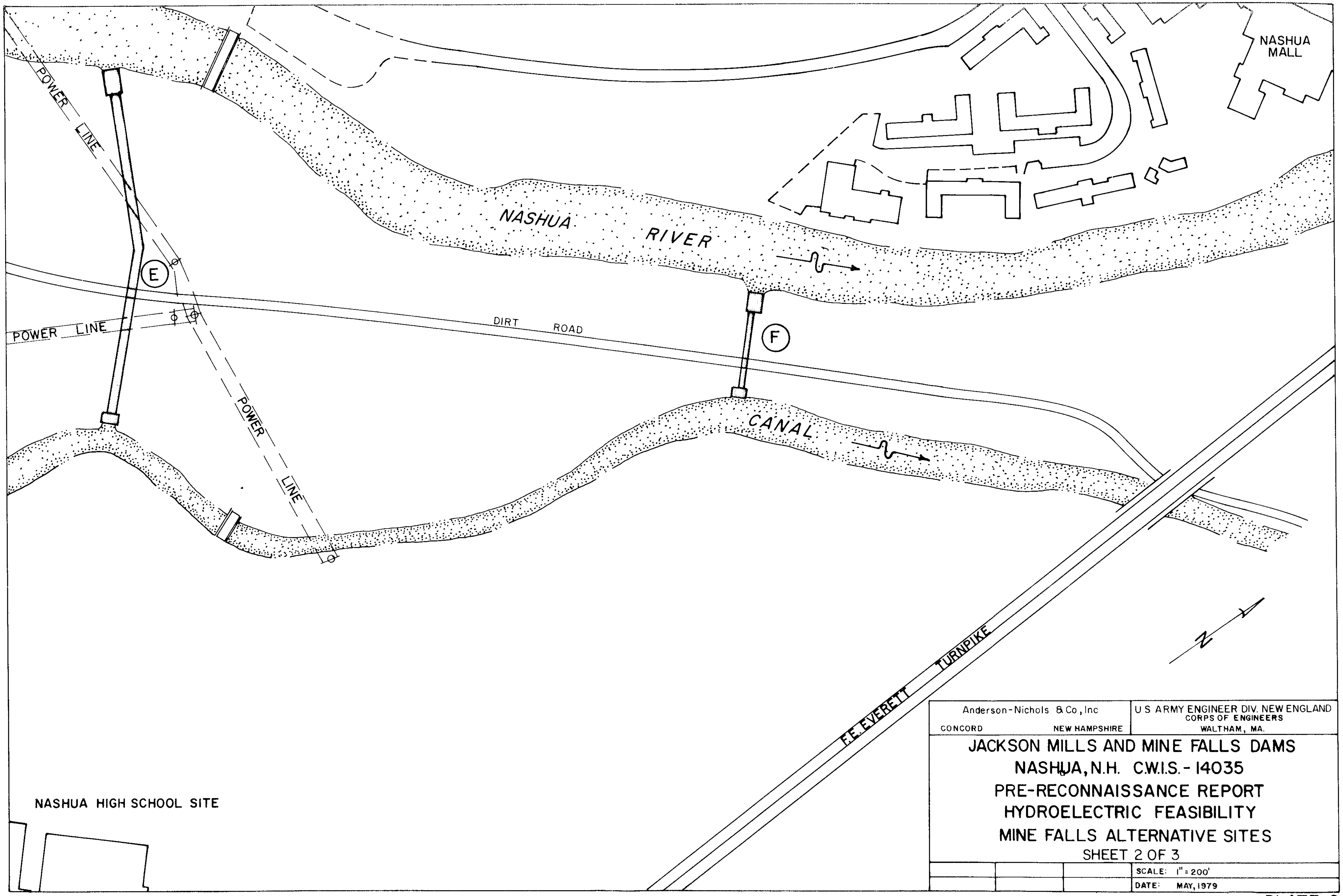
SCALE: 1"=20'
DATE: MAY, 1979

PLATE 6



A
B
C
D
E
NASHUA RIVER
NASHUA RIVER
POWER LINE
DIRT ROAD
EXISTING GATE HOUSE
POWER TRANSMISSION LINE
TAILWATER CANAL
CANAL
PUBLIC WORKS GARAGE SITE
EXISTING OVERFLOW WEIR
MILL POND
EXISTING OVERFLOW WEIR
NASHUA HIGH SCHOOL SITE
N
Anderson-Nichols & Co, Inc
CONCORD NEW HAMPSHIRE
U S ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MA
JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S.-14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
MINE FALLS ALTERNATIVE SITES
SHEET 1 OF 3
SCALE: 1" = 200'
DATE: MAY, 1979

PLATE 7

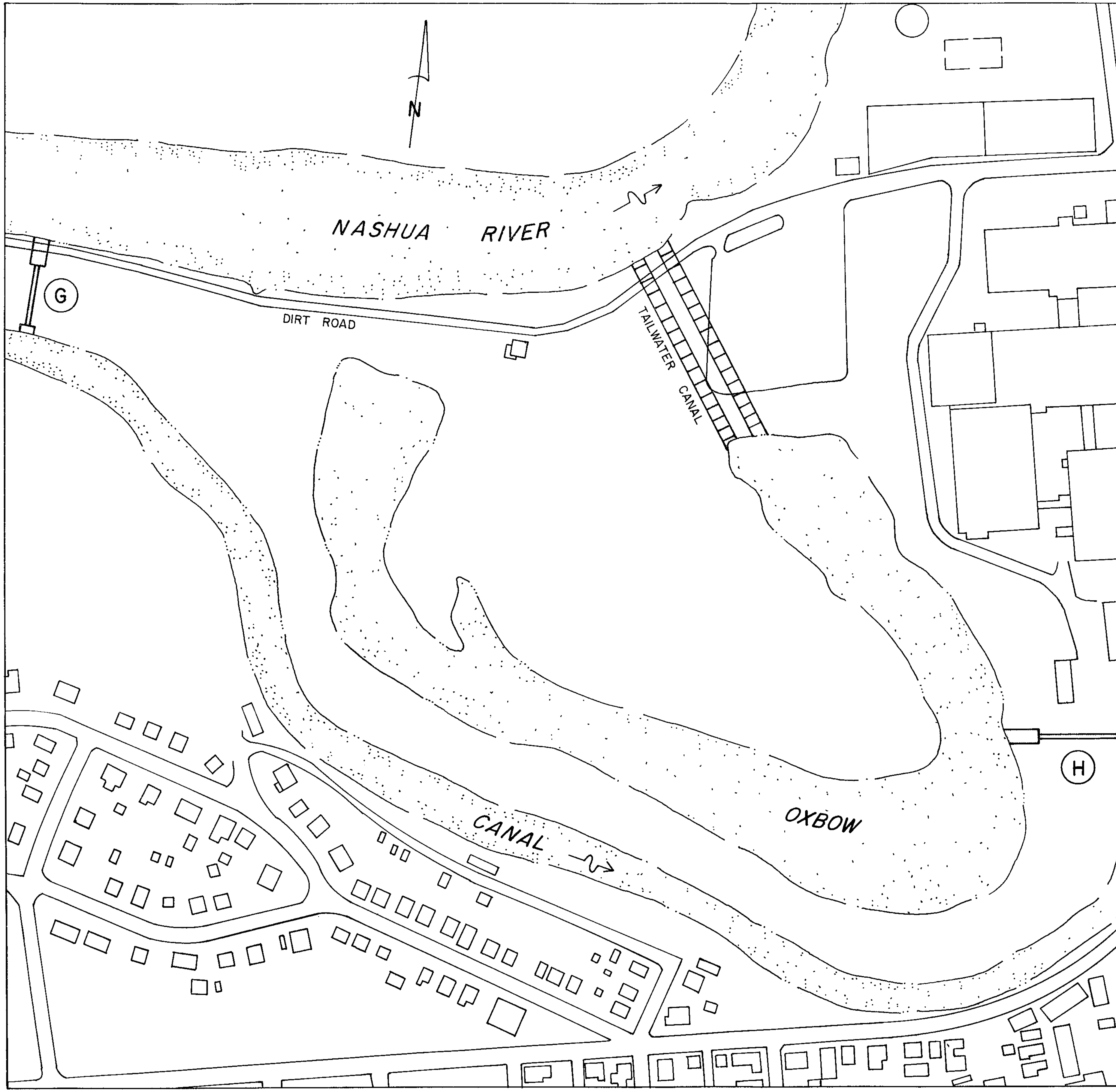


Anderson-Nichols & Co, Inc CONCORD NEW HAMPSHIRE	U S ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA.

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S. - 14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
MINE FALLS ALTERNATIVE SITES
SHEET 2 OF 3

SCALE: 1" = 200'
DATE: MAY, 1979

PLATE 8

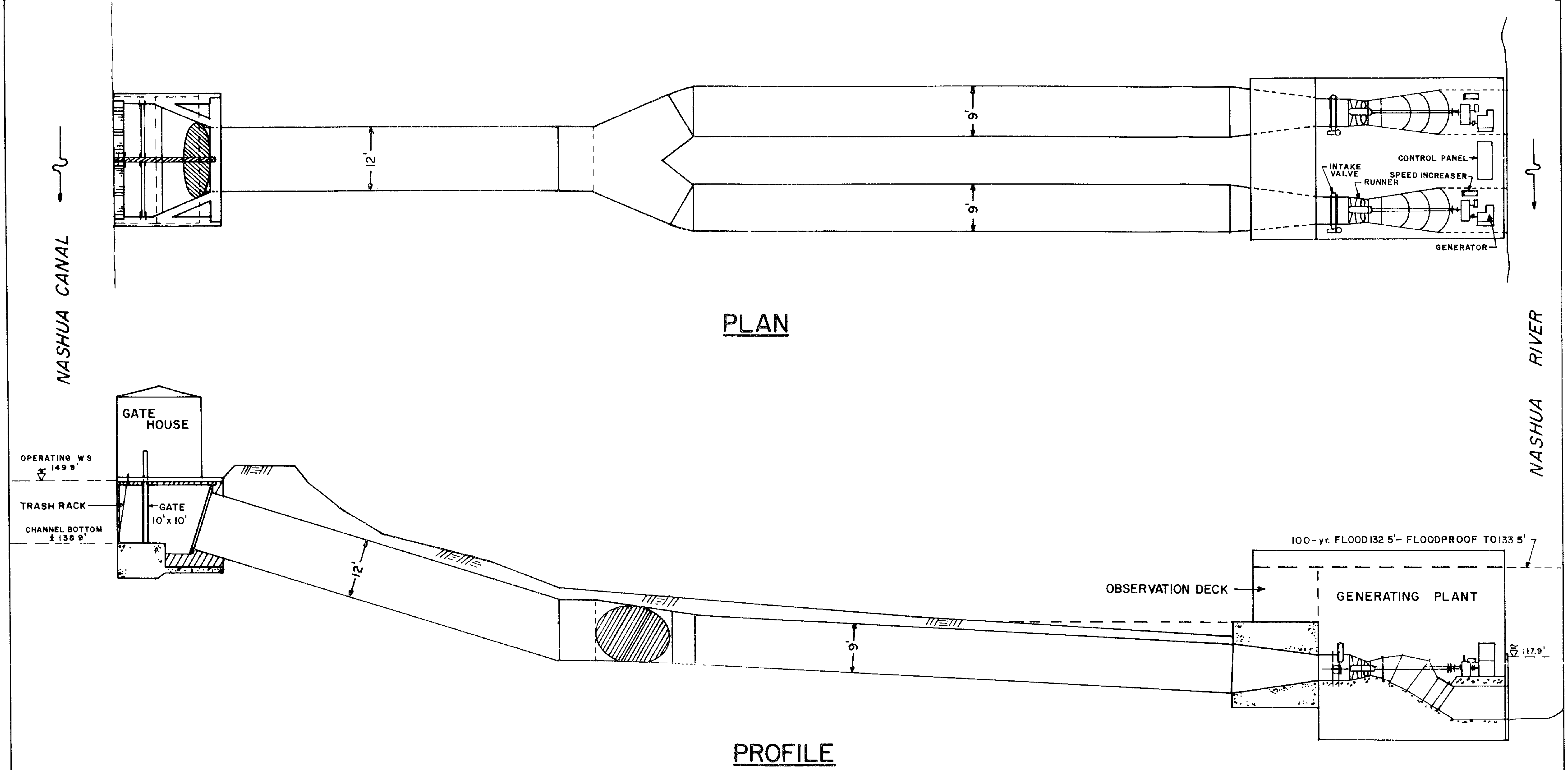


Anderson-Nichols & Co, Inc.
CONCORD NEW HAMPSHIRE

U.S ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MA

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S.- 14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
MINE FALLS ALTERNATIVE SITES
SHEET 3 OF 3

SCALE: 1"= 200'
DATE MAY, 1979

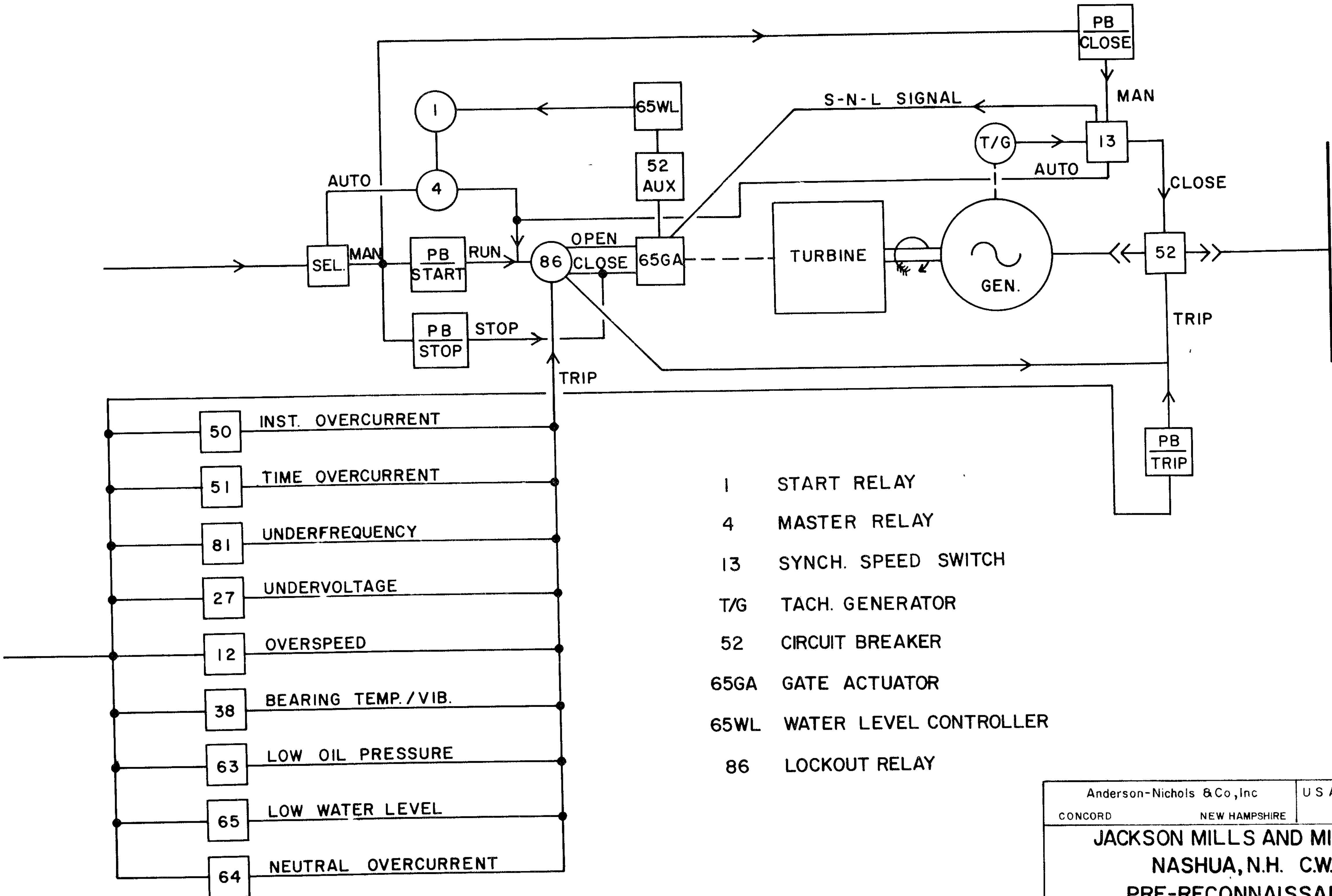


Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA.

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S.-14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
MINE FALLS CANAL SITE

SCALE: 1" = 20'
DATE: MAY, 1979

PLATE 10



1	START RELAY
4	MASTER RELAY
13	SYNCH. SPEED SWITCH
T/G	TACH. GENERATOR
52	CIRCUIT BREAKER
65GA	GATE ACTUATOR
65WL	WATER LEVEL CONTROLLER
86	LOCKOUT RELAY

Anderson-Nichols & Co, Inc
CONCORD NEW HAMPSHIRE

U S ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MA

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, N.H. C.W.I.S.-14035
PRE-RECONNAISSANCE REPORT
HYDROELECTRIC FEASIBILITY
BLOCK DIAGRAM
CONTROL & PROTECTION INDUCTION GENERATOR

SCALE: NOT TO SCALE
DATE: MAY, 1979

PLATE 11

REFERENCE LIST

1. U.S. Army Corps of Engineers, Jackson Mills Phase I Dam Inspection Report. Goldberg, Zoino, Dunnicliff & Assoc., Inc., February 1979.

2. U.S. Army Corps of Engineers, Mine Falls Phase I Dam Inspection Report. Goldberg, Zoino, Dunnicliff & Assoc., Inc., March 1979.

3. Energy Law Institute, Legal Obstacles and Incentives to the Development of Small Scale Hydroelectric Power in New Hampshire. Concord, New Hampshire: Franklin Pierce Law Center, January 1979.

4. Camp Dresser and McKee, Water Quality Management Plan Nashua River Basin. Boston: Camp Dresser and McKee Inc., December 1975.

5. Dingman, S. Lawrence, "Synthesis of Flow-Duration Curves for Unregulated Streams in New Hampshire", Water Resources Bulletin, December 1978, p. 1481.

6. U.S. Geological Survey, Water Resources of the Nashua and Souhegan River Basins, Massachusetts. Atlas HA-276, 1977.

7. Quinn, Joseph F., State of New Hampshire Department of Resources and Economic Development. Interview, 26 April 1979.

8. State of New Hampshire, Public Utilities Commission. Report on Rates for Sale of Power by Limited Electrical Energy Producers, 1979.

9. Morris, Henry M. and James M. Wiggert, Applied Hydraulics in Engineering. New York: The Ronald Press Company, 1972.

10. Hillsborough County Registry of Deeds, Quit Claim Covenants. Book 2067, pp. 228-231, 12 February 1970.

11. Hillsborough County Registry of Deeds, Conservation Easement. Book 2290, pp. 295-296, 13 April 1973.

12. Smith and Hamilton, Report on Mine Falls Park Mill Pond and Canal System. Concord, New Hampshire: Smith and Hamilton, Inc., July 1975.

13. Energy Law Institute, Federal Legal Obstacles and Incentives to the Development of the Small Scale Hydroelectric Potential of the Nineteen Northeastern United States. Concord, New Hampshire: Franklin Pierce Law Center, January 1979.